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Great Smokies Streams Acidified By Anakeesta Formation Exposures

By Darlene J. Kucken, Richard P. Maas, and Steven C. Patch

Exposed Anakeesta Formations, located within the Great Smoky Mountains NP (GSMNP) along Anakeesta Ridge, have long been known to cause negative impacts on aquatic ecosystems. Anakeesta Formations are composed of pyritic and carbonaceous slate and phyllite, which when exposed to air and water oxidize and form leachate containing sulfuric acid, iron, and other heavy metals such as zinc, manganese, and aluminum. In 1964, when a section of U.S. Highway 441 through the GSMNP between Cherokee, NC and Gatlinburg, TN was reconstructed, large Anakeesta Formations were disturbed and used as roadfill material at Newfound Gap. The chemical composition of Beech Flats Creek (BFC), previously a favored pristine trout stream, was severely and perhaps permanently altered by this construction disturbance, rendering it virtually lifeless.

The headwaters of BFC begin just below Clingman's Dome Road, flow under U.S. Hwy 441 at Newfound Gap, and eventually flow into the Oconoluftee River. The extent of stream chemistry alteration was first documented in 1975/76 (Bacon and Maas, 1979), when an attempt was made to determine stream recovery as a function of downstream distance from the source of Anakeesta. A follow-up water chemistry study was conducted from spring 1988 through summer 1990 (Maas et al, 1990) (Kucken, 1991) and the results compared to the 1975/76 study to determine whether significant changes in stream conditions had occurred over the 15-year period.

Author taking mid-winter *water sample from site of entry to Beech Flats Creek.*

Upper reaches *of Beech Flats Creek in spring.*

Research Methods

Grab samples were taken at approximately 3-week intervals from April 1988 to August 1990 at 8 sites on BFC downstream of the Hwy 441 roadfill at Newfound Gap (Fig. 1). The 8 sites were chosen to be consistent with those used in the 1975/76 study. Grab samples also were taken from various small sidestreams and springs feeding into BFC. Sampling began at Site 8 (3960 ft) to avoid disturbing the streambed, and continued upstream past Site 2, just below the roadfill area, to Site 1 (5349 ft) located above the fill area and thus presumed to be a good control site.

The sites were spaced to account for sidestream inputs and mixing zones and covered a 3-mile length of stream. All samples were analyzed for zinc and manganese by atomic absorption spectrophotometry, and for pH. Streamflow was measured at Sites 1,2, and 8 at the time of grab sampling, using a Mini Current Meter. Statistical analysis focused on determining differences between pH, Zn, and Mn in 1975/76 versus 1988-90, and on determining correlations between streamflow, acidity, and metal concentrations.

Results of Stream Samplings

A. Acidity

A statistically significant decrease was found in mean pH at the control site, Site 1 (Fig. 1), between 1975/76 [pH = 6.69(+/−.06)] and 1988-90 [pH = 6.31(+/−.04)], a decrease in ambient pH that is of great interest. Field investigation revealed that BFC splits into two forks; one flows intermittently as a result of rainfall, the other is a continuous flow. It was discovered that the intermittently flowing fork has a lower

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PARK SCIENCE

NATIONAL PARK SERVICE

WINTER 1992

A report to park managers of recent and on-going research in parks with emphasis on its implications for planning and management

ARTICLES

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MISCELLANEOUS

editorial

By this time, almost everyone in "the field" has heard the news that the 75th Anniversary Conference at Vail, Colorado, was not your usual run-of-the-mill self-improvement exercise. Despite the earnest iteration of lofty goals and promised results, those of us who have been around for longer than "awhile" were not on tiptoes with expectancy. In fact, the opening day saw a lot of conversation knots where I've-been-here-so-many-times-before was the central theme.

So imagine our surprise – then delight – then, well, almost elation, when the sessions turned into real down-and-dirty discussions about a whole host of things that have been bugging us for lo-these-many – when the leaders of the working groups and the plenary session speakers began to talk in tones seldom heard at such conferences. Instead of the usual self congratulatory droning, we heard the NPS's real needs for change described, deplored, and then turned over to the working groups for suggested reform ACTION. And the groups didn't fudge. They tackled the issues with the energy and thought they so desperately need, and the process is continuing at near boiling point.

There isn't room (nor is it this publication's appropriate task) to enumerate the recommendations and the conference-generated revisions that took place under the four headings: Organizational Renewal, Resource Stewardship, Park Use and Enjoyment, amd Environmental Leadership. It **is** within our purview to suggest that everyone in the Service should be participating strenuously in the process now underway, the outcome of which will be the Report to the Director.

And here's another encouraging straw in the wind: The Director was **there** throughout the entire conference. So were most of the plenary speakers and all the workshop leaders. And almost every one of the 600 participants stayed through the entire three days and took heated part in all the sessions and work groups. They began with our NPS idea and mission and then proceeded to outline just how far short of these ideals our past budgets and leadership have allowed us to fall. Twice during his address to the conference, Secretary Luhan told the delegates that park resources preservation must take precedence over visitor uses.

There was more than aplenty that will affect the field, its research activities and its management mission. Every park unit and office in the Service has received copies of the post-Symposium issues and preliminary recommendations. The period for public comment closed on Dec. 13. The Working Groups' final reports to the Steering committee are scheduled for completion in early January, after which the Steering Committee will prepare the final report to the Director.

I hope this is not a premature paeon of praise. It **is** a heartfelt thank you to the Steering Committee that put the Service on the line, to the outsiders – experts, critics, friends, and advisors – who told us how we looked to them and made strong suggestions as to what we should do about it, and to the Park Service that called this group into being and then bravely stood up and took the flak it had invited.

Hurray for us all!

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Annakeesta Formation Exposures Source of Acid in Streams

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pH, as well as pulses of heavy metals. The decrease in ambient pH could suggest two possibilities: (1) long-term effects of acid deposition on water quality in the GSMNP, or (2) acidification of the headwaters of BFC due to disposal of Anakeesta rockslide debris over the edge of Clingman's Dome Road at the headwaters of the intermittently flowing fork.A8AFurther research will be needed to ascertain whether either, or both, of these possibilities are causing increased acidity at the control site.

The mean pH at Site 2 did not change significantly between 1975/76 and 1988-90. In spring 1988 a sidestream between Sites 5a and 5b was found to be acidic (mean pH = 4.9) with high concentrations of heavy metals. This represents a significant change from the 1975/76 study, in which this sidestream expressed a mean pH = 6.0. Field invetigations revealed the probably source of acidification to be Anakeesta rockslide debris that was disposed of over the edge of the old U.S. Hwy 441 roadbed in the headwaters of this sidestream.

B. Zinc

A significant increase in median Zn concentrations between 1975/76 (<1.0ppb) and 1988-90 (15.0ppb) was observed at the control site, indicating that exposed Anakeesta may be the cause of water chemistry changes observed at Site 1. Median Zn concentrations decreased significantly at Site 2 between 1975/76 (146.0ppb) and 1988-90 (68.8ppb). There was no significant change in concentrations at Site 8, presumably due to the input from the acidic sidestream between Sites 5a and 5b, which often is high in Zn concentrations. Although these levels are significantly higher than background levels for this region, they are not high enough to be of ecological concern.

C. Manganese

Median manganese concentrations increased slightly at Site 1 between 1975/76 (<1.0ppb) and 1988-90 (4.0ppb). However, immediately below the Anakeesta roadfill area at Site 2, the median Mn concentrations increased significantly between the two study periods (210.0ppb versus 572.0ppb). The change in median concentrations observed in the lower reaches of the stream (23.0ppb versus 24.0ppb at Site 8) is not significant and cannot be explained by a simple dilution mechanism, especially since the acidic sidestream is relatively high in Mn. Evidently, chemical precipitation rather than dilution acts as the controlling mechanism for Mn removal (Maas et al, 1990).

The hydrolysis of Mn to an insoluble precipitate is favored under the less acidic conditions of the lower stream reaches. The high concentrations of Mn in the upper reaches of BFC and the acidic sidestream are of ecological concern due to their toxicity to many benthic organisms such as caddisflies, mayflies, and crayfish, and the trout that feed on them.

Summary of Study Results

Beech Flats Creek is experiencing acidification and heavy metal contamination due to the exposure of Anakeesta Formations, which have negatively impacted stream ecology. Anakeesta Formations have had similar impacts on other streams in the GSMNP. There have been no significant improvements in water quality since the 1975/76 study. Overall water quality has degraded somewhat over the 15 years between studies. Mean pH along the stream's length has not increased significantly. Of particular interest is the decrease in pH at the control site above the roadfill area. Possible explanations for this are (1) the long-term effect of acid deposition in the GSMNP; (2) leachate from exposed pyritic rockslide debris that has been dumped over the edge of Clingman's Dome Road, or (3) a combination of (1) and (2).

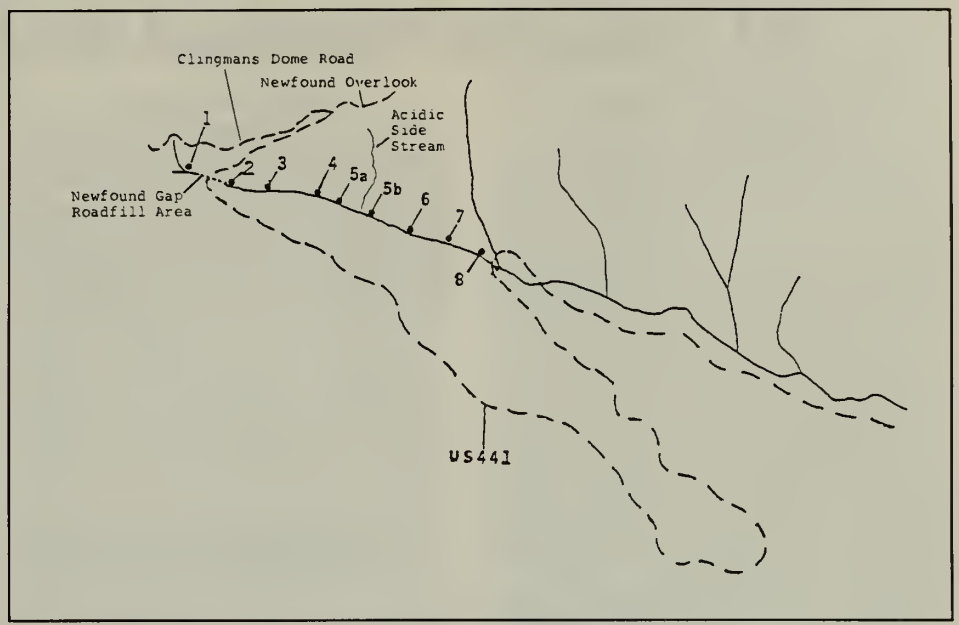

Figure 1. *Beech Flats Creek Sample Sites in the Great Smoky Mountains NP.*

Site of roadcut *and Anakeesta road-fill placement above Beech Flats Creek in GSNP.*

While median concentrations of Zn have increased at the control site (perhaps due to the Anakeesta debris dumped from Clingman's Dome Road), concentrations have decreased significantly at Site 2 since the initial study. The present levels of Zn in BFC are higher than expected ambient levels, but are not of ecological concern.

Median concentrations of Mn have not changed at the control site, but have significantly increased at Site 2, below the roadfill area. One possible explanation is that as the Anakeesta continues to fragment over time, a greater surface area, which may contain higher levels of Mn, is exposed. The reaction of Mn in the stream is pH dependent, so it may be assumed that Mn originating from the Hwy 441 roadfill area, as well as from the acidic sidestream, undergoes rapid hydrolysis to an insoluble precipitate in the lower reaches of BFC.

The absence of significant water quality improvements over this 15-year period suggests that natural processes alone will not restore Anakeesta affected streams such as BFC to life-supporting conditions within the foreseeable future. It is suggested that remedial mitigation be undertaken to increase the recovery rate of not only BFC, but of other GSMNP streams similarly negatively impacted by naturally-occurring exposure of Anakeesta materials.

Compound Anakeesta slide scars within GSMNP have increased greatly in area and volume since 1953 (Ryan 1989), and new slide exposures continue to occur. Due to the fracturably nature of Anakeesta Formations it is expected that disposal of rockslide debris will continue to be a difficult challenge for NPS man-

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A New Approach to GIS Implementation At Colonial National Historical Park

By Hugh Devine, Charles Rafkind, Jean McManus, and John Karish

Colonial National Historical Park is a 9,327 acre park along the James and York Rivers, comprised of Jamestown Island, Yorktown Battlefield, the Colonial Parkway, Green Springs, and Swann's Point. For the past year the Geographic Information System (GIS) Research Group of the College of Forest Resources at North Carolina State University (NCSU) has been working with Colonial NHP to develop a GIS implementation plan.

The plan is unique in three ways. First, it outlines a phased implementation program for a park based system to service the full range of park management activities. Second, Colonial is basically a medium size cultural park (with significant natural resources) and most national park GIS efforts to date have focused on large natural resource based parks. Third, the implementation is designed to allow distributed access to the GIS through the three major park divisions as opposed to a single centralized system as is characteristic of most natural resource GIS applications. The park divisions include resource manaagement and visitor protection, maintenance, and historic interpretation and preservation.

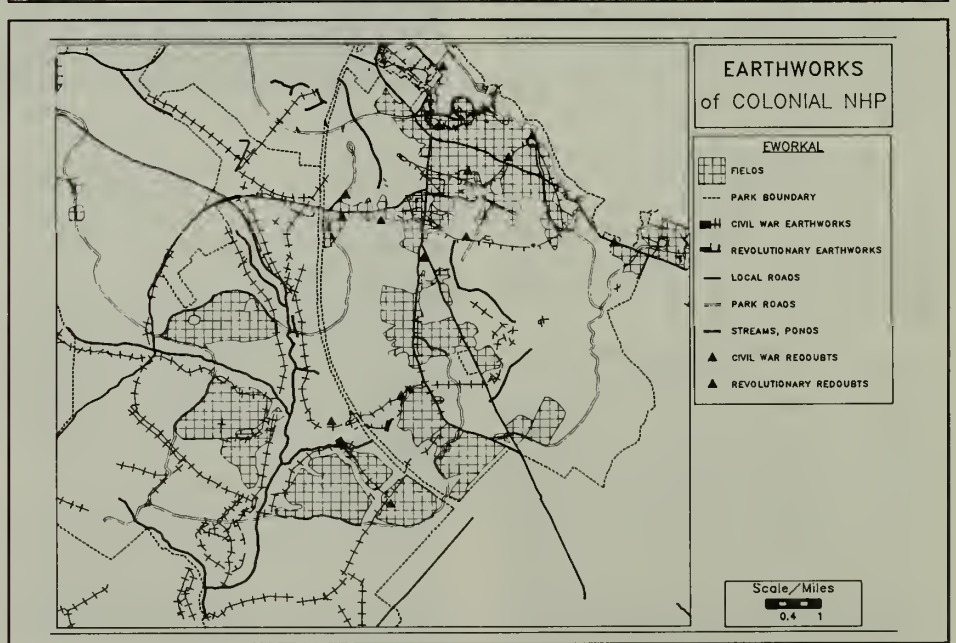
Training and Needs Assessment

The assessment of needs was performed through a training session, followed by a series of interviews to determine prioritized division needs. Considerable time was spent training managers in both the potentials and costs of GIS for their divisions prior to determining the list of map needs. A brief written description of GIS for park management was prepared and distributed to the Colonial participants in advance of the training.

Training was completed in one full day at Colonial. A morning session focused on introducing a large cross section of the park staff to GIS and its potential for management. This session was completed in about three hours and included a variety of visual aids – video tapes, 35mm slides, and overhead transparencies.

The afternoon session concentrated on developing a more detailed exposure to GIS for Colonial division chiefs and selected staff. This session, again about three hours, was designed to allow participants to work through an actual mapping exercise using Colonial data. Three computer work stations were used, in what was intended to be a step-by-step group experience in construction and plotting of a Jamestown Island vegetation map. However, the participants were quite able to work independently and the anticipated group technique was neither necessary nor efficient. The procedure, therefore, was shifted to three individual instruction efforts (i.e. one per station) with an instructor assigned to each group. The groups then proceeded at their own pace to produce the planned map, plus several variations.

The session also included a demonstration of a Computer Aided Design (CAD) system and a digitizing procedure. In addition, because of its informal structure, this session involved extensive question and



Anakeesta Acid

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agement. While it is assumed that covering the debris materials with soil and vegetation will reduce or eliminate the oxidation processes, it is not known how much soil and what type of vegetation will work best to reduce the formation of acid and metal leachate into GSMNP streams.

Research currently is being planned for on-site plot experiments to determine what depth of topsoil cover is required to reduce the formation of acid and metal leachate to the levels necessary to re-establish viable aquatic ecosystems. This proposed research will provide the necessary information for determining whether, and to what extent, streams such as BFC could be restored to viable trout streams through a strategic, low cost program of soil cover introduction. It is hoped that this method of mitigation will prove a permanent and low cost solution to an on-going and extensive problem within the GSMNP.

Kucken is Research Associate with UINC-Asheville Environmental Quality Institute; Maas is Director of the Institute; Patch is Assoc. Prof. of Statistics at UINC-Asheville.

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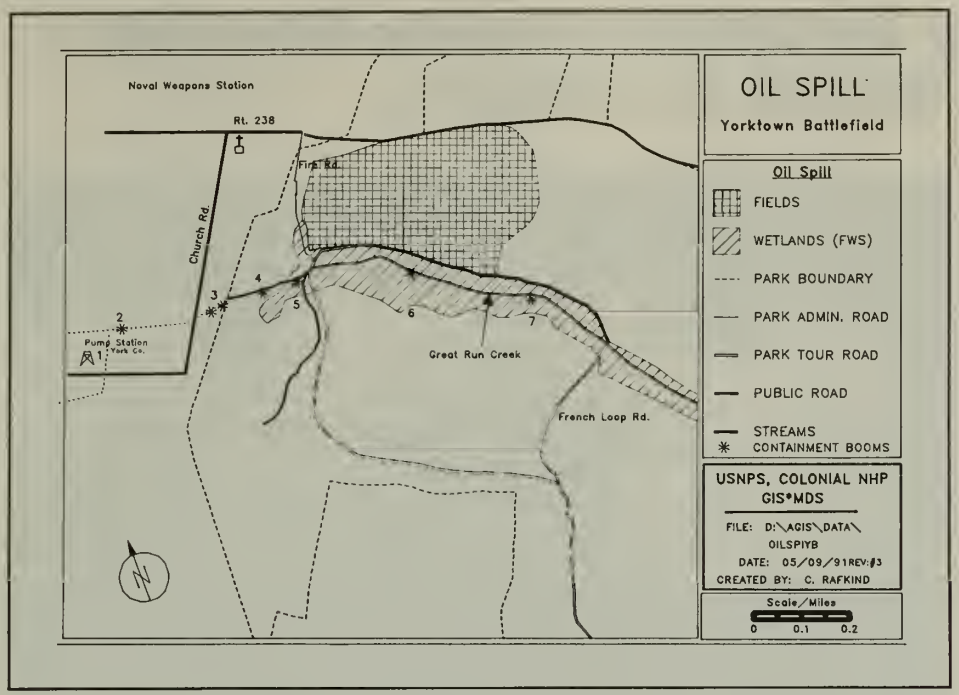

answer periods concerning GIS, CAD, and related computer and management topics.

Training Session Evaluation

Two recommendations for the training session were developed. The afternoon session should be designed to treat each management function separately; that is, each division should work with its own data and should produce a product relevant to its own needs. Secondly, a standard set of visuals for NPS GIS instruction should be developed.

The development of recommendations for a GIS at Colonial hinged on identification of management's need for mapped information. Such an identification can come only from the managers and users themselves, after they have considered the importance of mapped information in their operations and have evaluated the potential of GIS to produce and manipulate such data.

The training was followed by two days of interviews, which led potential park users through the process first of identifying the role of maps in their tasks, and then enumerating the types and sources of these maps. The information from the survey forms was used to catalog the responses of division personnel and to develop a map theme list.

Recommendations

Evaluation of GIS alternatives for the park was based on three criteria: (1) the appropriateness of raster versus vector data structures, and the need to exchange digital data with other GIS users (local government, state and university systems), (2) the ability to have several park divisions benefit from, and use, the GIS immediately, and (3) realistic staffing, budgeting, and training levels that the park could commit to a GIS.

The recommended GIS software is ATLAS*GIS with appropriate data exchange modules. The choice of ATLAS*GIS was dictated by the low initial cost, user friendly menu system, minimal training requirements, capacity to perform the mapping analyses and production task identified in the interviews, and conversion abilities to and from ARC/INFO. ARC/INFO is used by all government jurisdictions that surround the park, and data exchanges will be performed on a regular basis. USGS, EPA, State of Virginia, Council on the Environment GIS, and VA Institute of Marine Science are the cooperators with whom the park exchanges data regularly.

Current and Future Direction

Currently, the park is developing a series of data themes for the GIS. These themes are being prepared under agreements with the NCSU GIS Research Lab, VA Institute of Marine Science, and the USDA Soil Conservation Service (SCS). During March 1989, winter aerial photography was flown using 70mm true color film at 1:12,000 scale. From this photography, NCSU has interpreted, delineated, and digitized vegetation types, wetlands, streams, ponds, earthworks, roads, and adjoining landownership use (residential, military, commercial), and rare species occurrences and critical habitats. In addition, several communities surrounding the park are developing themes useful for park management (e.g. floodplain, topography, utilities, and tax parcel ownership maps). State agencies have provided USGS digital line graph information on roads, shorelines, hydrology, and political boundaries.

Current efforts also include compilation of the numerous historical and archaeological base maps for Jamestown Island into one data base and map, input of the 100+ right-of-way grants involving road access, security fencing for military bases, and numerous types of public utilities. The soil surveys for the park and a 1000 foot buffer are being recompiled and digitized by SCS. The VA Institute of Marine Science will provide watershed and sub-basin information, near surface geology, water quality and quantity data, floodplains, aquifers, springs, seeps, recharge areas, non-tidal and tidal wetlands. NCSU is developing UTM and Long/Lat grid overlays for wildlife sightings, fire management, and vegetation management projects, road kilometer marking overlay, and a series of applications dealing with historical vegetation pattern changes, adjoining potential developable lands/viewshed impacts, and fire unit maps of values at risk.

The park and NCSU are continuing to develop standard operating procedures to guide the development of new geographic and database files, and cartographic map production. Areas covered include file and attribute naming, database attribute development, quality control, and primary and secondary naming procedures for geographic data. With a leading cartographer from NCSU we are developing a GIS feature taxonomy covering colors, patterns, symbology, and sizing for maps produced on plotters and B/W laser printers. All this will be the focus of a future article.

These themes/databases will be used for fire management, habitat analysis, open fields management, earthwork vegetaion management, wetland identification and preservation, and cultural resource management. Other analyses will include shoreline erosion, land cover and water quality changes, and information calculations (number of acres of Class A, B, or C lawns, acres of the different types of wetlands, miles of earthworks, boundaries, shoreline or trails, number of historic sites).

The park's GIS system already has played an important role in environmental analysis, in response to oil spills, special events, wetlands, vegetation, fire, and air quality management planning, development of new mowing regimes for the park's 1,100 acres of open fields, RTE survey, fire reporting, and historical research into changing vegetation patterns over the past 380+ years.

Dr. Devine is director of the NCSU GIS Research Laboratory and a professor in the College of Forest Resources; Rafkind is Natural Resource Management Specialist at Colonial NHP; McManus is manager of the NCSU GIS Research Lab; Karish is Mid-Atlantic Regional Chief Scientist and GIS Coordinator.

In the Next Issue

The ***Park Science*** Spring issue will contain several articles describing research on marine and terrestrial ecosystems in Virgin Islands NP. Much of the ongoing work builds on previous studies by members of the Virgin Islands Resource Management Cooperative (see Rogers and Zullo, Spring 1985 ***Park Science***, cover and p.3).

A number of studies are addressing the long-term effects of Hurricane Hugo, which swept through the U.S. Virgin Islands in September 1989. The park's research staff has quantified the effects of this powerful storm on long-term transects established on a coral reef in the park. Under a Cooperative Agreement, scientists from the U.S.V.I. Division of USFWS have censused coral reef fish assemblages at several sites inside the park and documented storm effects.

Scientists from U/GA, U/WI, and the Institute of Tropical Forestry have recorded the hurricane's effects on long-term plots established in the dry and moist forests of St. John. Also, in 1991 as part of a network of MAB biodiversity sites, the Smithsonian established a long-term plot in a dry forest area on the island.

In addition, the Soil Conservation Service recently mapped the soils in two watersheds and established automatic data sensors that record soil termperature and moisture at several depths. The USGS and NPS will be collaborating in a paired watershed study to compare sediment loads from a developed and an undeveloped watershed.

Great Smoky Mountain Plants Studied For Ozone Sensitivity

By David Hacker and James Renfro

Plants suffering from the ill effects of a variety of air pollutants are causing widespread concern within the National Park Service. Effects can vary greatly, some plants exhibiting no symptoms, some showing reduced vigor, and some suffering widespread tissue necrosis and death. Injury is not limited to individual plants, but may also be displayed on a community or ecosystem level.

Since 1986, putative ozone injury symptoms have been observed on over 70 native species of plants in Great Smoky Mountains NP (GRSM). GRSM contains more than 1500 native plant species and is one of the largest temperate forest reserves in North America. Ozone (O_3), with its widespread distribution, probably has the greatest negative impact on vegetation of all air pollutants (Reich 1987, Krupa and Manning 1988, de Steiguer et al. 1990). Ground level or tropospheric ozone is a secondary pollutant formed by the reaction of sunlight on the primary pollutants of nitrogen oxides and hydrocarbons. Ozone levels in GRSM rarely exceed the National Ambient Air Quality Standard (NAAQS), but moderate chronic levels do exist.

Ozone is an extremely phytotoxic air pollutant. Ozone enters the plant through the stomata, which are the small pores on the underside of the leaf. Once the ozone is inside the substomatal cavity of the leaf interior, the possibility for foliar injury is present. At low concentrations, typically the first sign of ozone damage is a water-soaked appearance of the leaves. This occurs because of loss of water into the intercellular spaces, due to the loss of membrane integrity. If the ozone stress is removed, the cell membranes may repair themselves and the symptoms disappear. If exposure continues or increases, flecking or stippling may appear followed by chlorosis and then necrosis (Tingley and Taylor 1982).

Ozone, being a very unstable substance, reacts in water and/or with organic compounds to form a number of highly toxic oxides, including O_2 – superoxide; H_0 – hydroxyl; and H_2O_2 – hydrogen peroxide. All these compounds can react with cellular membranes causing damage.

Damage arises primarily from reactions with lipids or fats that are constituents of membranes. For example, superoxide can cause the double bond in the fatty acid half of a lipid to convert to a single bond. The properties of the lipid then are changed, and if enough lipids are altered, the membrane properties are modified.

Ozone itself reacts strongly with saturated fatty acids and other organic compounds, hence disrupting membranes (Heath 1980). Severe ozone exposure may even result in the cleavage of the fatty acid half of a lipid, giving rise to toxic 3C compounds. Ultimately these damaging effects lead to reduced photosynthesis (Reich and Amundson 1985, Reich 1983), modified carbon allocation (McLaughlin and McConathy 1983), or even death of the individual.

Scientists' estimates of percentage annual growth changes due to air pollution for the high elevation spruce-fir forests in the Appalachians varied from -2 to -70 percent, with a median estimate of -10 percent (de Steiguer et al. 1990). These estimates reflect only growth reduction and not air pollution induced death.

A study initiated by the NPS Air Quality Division and GRSM in 1986 was undertaken to characterize the adverse effects of ozone on plants native to GRSM. This study is documenting the physical as well as the dynamic responses individual species exhibit to exposure to ozone. In 1989, the EPA funded a three-year program to study the physiological responses of ozone on selected plant species native to GRSM. This project also is being conducted at the GRSM's Uplands Field Research Lab fumigation site. Together, the NPS and EPA will be able to address the chronic problems of ozone pollution on GRSM plants.

Figure 1. *The Ozone fumigation site at Uplands Research Lab.*

Methods

Plants native to GRSM are examined in the field to determine if they exhibit any typical or classic symptoms of ozone sensitivity. If a species appears to be ozone sensitive, a specimen is brought back to the lab for verification of ozone damage. Once putative ozone damage has been determined, that species is listed for future ozone fumigation at Uplands Field Research Lab. To date, 74 species of plants in GRSM have exhibited putative ozone injury.

With the conclusion of the 1990 field season, 31 species of plants native to GRSM have been subjected to a gradient of ozone concentrations. In the experiment, plants are cultivated from seed collected in the park. Seedlings are grown in individual pots and are placed in one of 15 open-topped growth chambers or three open plots. This allows for three replications of six treatments.

Treatments include 0.5 x ambient, 1.0 x ambient, 1.5 x ambient, 2.0 x ambient, carbon-filtered, and open-ambient plots. All treatments except the carbon-filtered are proportional to ambient ozone concentrations in order to give a better reflection of what vegetation in GRSM is exposed to. Ambient concentrations are continuously monitored and treatments are updated every two minutes. In addition to monitoring ambient ozone concentrations, all meteorological parameters and CO_2 and NO_2 concentrations are analyzed and recorded on a data logger and computer.

Technicians water the plants manually to ensure that all individuals receive enough water for soil saturation and luxury consumption. This is done because drought has been demonstrated to be a mitigating factor to ozone injury (Reich 1987).

Plants are visually inspected for incidence, extent, and symptoms of ozone damage periodically throughout the growing season. All species are photo-documented for all types of injury in all treatments. Full descriptions of ozone damage are documented and recorded. Growth measurements such as height and diameter are routinely documented at the beginning, the end, and at regular intervals during the growing season. Several phenological measurements are taken on herbacous species including flower count, flower incidence, and seed weight. Most of the species are harvested at summer's end, and leaf count, leaf area, and biomass allocation of roots and shoots are recorded.

Histological sampling also is performed throughout the course of the field season. Sampling of leaf tissue in the fumigation chanbers is compared to leaf samples collected in the field to verify that ozone is causing injury at the cellular level.

Results and Discussion

Twenty-five of the 31 species fumigated in the ozone exposure study displayed some degree of visible sensitivity to ozone. Typical symptoms in hardwoods and herbaceous plants varied, but generally small chlorotic patches would appear with the onset of ozone injury. As damage progressed, necrotic tissue would replace the chlorotic patches, giving a red or brown hue to the leaf. The leaf appeared to look "rusty." Commonly, visible ozone injury occurs on the surface of the leaf, usually in the interveinal areas and on older foliage.

If the disease progresses further, the dead leaf tissue expands, green tissue disappears, and the leaf blackens and dies. Conifers exhibit symptoms that differ from angiosperms. Instead of well defined stipple manifested on the top side of the leaves, conifers display a chlorotic mottled appearance. This is due to the

Table 1. GRSM ozone fumigation program plant testing and sensitivity list, 1987-1990

1987 – Species Tested	Common Name	Visible Sensitivity
1. *Acer saccharum*	sugar maple	R
2. *Angelica triquinata*	angelica	R
3. *Betula lutea*	yellow birch	SS
4. *Cacalia rugelia*	Rugel's ragwort	MS
5. *Euatorium rugosum*	white snakeroot	SS
6. *Glyceria nubigena*	manna grass	MS
7. *Lireodendron tulipifera*	yellow-poplar	ES
8. *Quercus alba*	white oak	R
1988 – Species Tested	**Common Name**	**Visible Sensitivity**
9. *Acer rubrum*	red maple	ES
10. *Cercis canadensis*	eastern redbud	MS
11. *Cornus florida*	flowering dogwood	MS
12. *Pinus pungens*	table-mountain pine	ES
1989 – Species Tested	**Common Name**	**Visible Sensitivity**
13. *Asclepias exaltata*	tall milkweed	ES
14. *Liquidambar styraciflua*	sweetgum	MS
Pinus pungens (12)*	table-mountain pine	ES
15. *Platanus occidentalis*	American sycamore	ES
16. *Prunus serotina*	black cherry	ES
17. *Rhus copallina*	winged sumac	ES
18. *Robinia pseudoacacia*	black locust	SS
19. *Rudbeckia hirta*	black-eyed susan	ES
20. *Rudbeckia laciniata*	cutleaf coneflower	ES
21. *Tsuga canadensis*	eastern hemlock	R
22. *Verbesina occindentalis*	crown-beard	ES
1990 – Species Tested	**Common Name**	**Visible Sensitivity**
Tsuga canadensis (21)	eastern hemlock	R
Pinus pungens (12)	table-mountain pine	ES
Asclepias exaltata (13)	tall milkweed	ES
Liquidambar styraciflua (14)	sweetgum	ES
Liriodendron tulipifera (7)	yellow-poplar	ES
Rudbeckia laciniata (20)	cutleaf coneflower	ES
23. *Aster acuminatus*	whorled-wood aster	MS
24. *Aesculus octandra*	yellow buckeye	MS
25. *Pinus virginiana*	Virginia pine	SS
26. *Krigia montana*	mountain dandelion	SS
27. *Sassafras albidum*	sassafras	ES
28. *Rubus canadensis*	thornless blackberry	MS
29. *Rubus idaeus*	red raspberry	R
30. *Magnolia tripetela*	umbrella magnolia	SS
31. *Pinus rigida*	pitch pine	R

*Plant species in parentheses were fumigated in previous year(s).

Sensitivity Codes:

ES – **E**xtremely **S**ensitive. Foliage exhibited injury (stippling or chlorotic mottle on all treatments equal to or greater than ambient). Ambient treatment injury on >50 percent of the plants. Incidence of injury in the 2.0 times ambient treatment was >90 percent. Symptomatology in chambers was similar to injury documented in the field.

MS – **M**oderately **S**ensitive. Exhibited injury to <50 percent of the plants in the ambient treatment and injury was documented on >50 percent of the plants in the 2.0 times ambient treatment. The symptomatology in chambers was similar to injury documented in the field.

SS – **S**lightly **S**ensitive. No injury was documented in the ambient treatment. Only visible injury documented in the 2.0 times ambient treatment, but <50 percent. Injury documented in the field only on several individuals (<5 percent sampled).

R – **R**esistant. Species did not show visible effects from ozone to the foliage of the plant in any of the treatments. Visible injury not observed in the field.

undifferentiated tissue conifers have in their needles; hence all the cells are equally sensitive to the effects of ozone.

Other symptoms of ozone damage on conifers are tip burn, which tends to be the first sign, overall chlorosis of the foliage, and necrotic lesions on the needles.

Sensitivity of plants to ozone exposure is ranked from very sensitive to resistant. In the GRSM study, it was discovered that many species indigenous to GRSM were sensitive to ozone, with 16 species being very sensitive, 5 species displaying moderate sensitivity, 4 species showing slight sensitivity, and 6 being resistant. Sensitivity based on visible symptoms by species is shown in Table 1.

With heightened public awareness of the problem of declining air chemistry, the need for continued research into the effects of air pollution on forest decline has never been greater. Ongoing research at Uplands Field Research Lab is quantifying the adverse effects of poor air quality and providing baseline data so that resource managers can make educated decisions.

Hacker and Renfro conduct air pollution research at the Uplands Field Research Lab, Great Smoky Mountains NP.

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Biodiversity Training Course

A highly acclaimed interagency training course, "Meeting the Biodiversity Challenge: A Shortcourse for Decision-makers," will be offered again this year by the BLM Phoenix Training Center, Charles Pregler, Wildlife Training Coordinator. Three NPS professionals – David Morris, Assistant Superintendent, Southern Arizona Group; Craig Shafer, Ecologist, WASO, and John Earnst, North Cascades NP superintendent – were enthusiastic in their praise of the benefits after taking the course last summer.

The course was developed by four federal agencies: BLM. USFS, USFWS, and the EPA. Instructors are drawn from around the world – experts active in government, academia, and the private sector. More than 100 top level managers and senior advisors from five major natural resource agencies, GAO, and Canada have attended the four previous sessions.

The workshops tackle such biodiversity preservation problems as human population growth, habitat fragmentation, spread of agriculture into refuges, lack of understanding of what biodiversity means, large federal water diversion projects, exotic species invasions, inadequate information bases, acid rain, defoliation, land ownership patterns, global warming, and more. The lecturers are recognized leaders in both action and theory of biodiversity and are available to help participants after formal class sessions.

But perhaps most important, according to NPS participants in prior sessions, is the interagency give and take – the growing recognition that emerges of how various agencies' problems and perspectives can be coalesced into more effective systems approaches to biodiversity problems. Class exercises emphasized broad-scale regional planning, an area where land management agencies are either playing catch-up or are becoming more aware of the need.

With two more courses being offered this fiscal year (see Calendar on this page), interested persons may contact James Lee, WASO training officer (202) 523-5280 or John Dennis, Chief, Science Branch, Wildlife and Vegetation Division, (202) 343-8128.

Professionalism in Resource Management

Editor's Note: The following is a synthesis of a workshop session at a national meeting of Regional Resource Management Specialists on July 23-25, 1991, and represents the general consensus reached, as it appeared to the author. Since the whole concept of natural resource management, as a profession, is still forming, and given the seemingly active state of evolutionary ferment within the National Park Service, this paper is presented for reflection and comment by our readers. As readers who are (or should be) vitally interested in this subject and all its implications, you are invited to respond, either in article or letter form, to the editor.

By Kathy Jope

To discuss professionalism in resource management, it is necessary first to define resource management, which has evolved as a profession only within the last 10 to 20 years. Given such a short history, it is not surprising that some confusion and disagreement still surround just what it is that a resource manager is supposed to do.

In 1980, Ro Wauer conceptually defined the resource manager as one who "not only works to solve today's problems but identifies and prevents those of tomorrow" (Wauer, 1980). He stated that a resource manager is a *catalyst* who talks to managers, scientists, planners, interpreters, and work crews, relates to the big picture,is responsible for implementation and monitoring, and has the time and staff to do it correctly.

A resource manager is not a researcher. However, resource management *is* closely linked to research. Gary Davis drew an analogy between NPS natural resource programs and the medical profession (Davis 1988). While medicine requires medical research to provide information, research alone doesn't keep the patient well. There must also be a doctor, who applies the results of that research. Similarly, the NPS requires research on park ecosystems, but research alone doesn't protect park resources. It is the role of the resource manager to apply the results of research and to serve as the "doctor" for the parks' natural resources.

This could be interpreted to imply that the resource manager is a technician, who unquestioningly follows the instructions of researchers and implements research recommendations. However, a professional resource manager goes beyond the research results. S/he is aware of alternative approaches, critically evaluates them, and selects the one most appropriate to a given situation.

Detecting a problem often requires in-depth knowledge of the resource and how it functions and interacts with others, resulting in sensitivity and ability to recognize situations in which something is not quite right. Defining a problem and developing an approach to resolve it requires skill in problem solving. To do this, a resource manager identifies information needs, determines what information is available from the published literature or other existing sources, and indicates what will require new research.

A foundation in science and critical thinking ability are essential in determining the relevance of particular studies to a given issue. These qualifications probably can best be obtained through a Master's degree in a natural resource discipline. (The needed qualifications exceed what is obtained through a Bachelor's degree. While a Ph.D. gives a better understanding of research design and scientific methods, its usually narrow focus contributes little to the range of capabilities needed in an effective resource manager.)

When research is needed to provide information not available in the published literature, in most parks the resource manager serves as research coordinator. In this role, s/he: (1) obtains needed funding by preparing funding requests, requests for proposals (RFPs), and other needed documentation; (2) works with the researcher in clearly defining research objectives and developing methods compatible with NPS mandates; (3) monitors progress of the research, and (4) reviews the research report for management implications.

It is not appropriate for the researcher to make management *recommendations.* Since management decisions are based on many other considerations of which the researcher may not be fully aware, the researcher should instead discuss management *implications* of the research findings, such as the likely consequences if the park selects a certain alternative action.

When scientific information is incorporated within a park's resource related programs, the differences between a resource manager and a researcher become clear. The resource manager is responsible for integrating scientific information, as appropriate, with other considerations to achieve the park's objectives for resource protection. Management decisions are not based solely on biological information, but on additional considerations that lie beyond the scope of the research – other information relevant to the issue, park management objectives, NPS management policies and regulations, effects on other park programs, and strategic judgment concerning the long-term benefits of alternative actions.

Achieving a resource protection objective may involve making use of management tools and procedures such as special use permits, concession contracts and commercial use licenses, cooperative agreements, and land use regulations and rights of ownership. The socio-political environment can create new opportunities for alternative approaches or make certain approaches unfeasible. The more knowledgeable a resource manager is in all these areas, the more effective s/he will be.

A resource manager can accomplish only a limited amount alone. Instead, the resource manager must work through others, such as work crews, maintenance, law enforcement, interpretation, public information, and concessions management. The resource manager serves as the focus of natural resource-related activites, helping the various programs work together toward doordinated resource protection rather than at cross purposes. To be effective, the resource manager needs a knowledge of the other park programs, their work requirements and procedures.

In managing a program, resource managers need to be skilled in managing staff and funding. They must be knowledgeable about administrative procedures and regulations and able to develop good working relationships with budget officers, procurement officers, classification specialists, and contracting officers.

They work not only with park employees, but also with personnel from other agencies, adjacent landowners, and interest groups. Thus, they need to be skilled in communication and interpersonal relationships, in negotiation and persuasion. They must be able to communicate effectively the technical information about the resources, threats to their integrity, research findings, potential solutions to problems, and the pros and cons of alternative approaches. This information must be presented in ways that speak to people representing diverse value systems and explain why it is in their interest to care about the well-being of park resources.

Resource managers are primary sources of information about park resources. Increasingly, they need ability in database management. This ensures that resource information is available when needed, that there is continuity over time, and that research results will not be forgotten when the manager transfers.

Resource managers must stay up to date with the most current scientific knowledge. We should think of resource managers as *scientific* resource managers. Unfortunately, because our staffing levels are so spartan, is has been necessary for a single resource manager to be responsible for an extremely broad spectrum of resources.

The GS-401 Biologist classification does not begin to reflect the range of responsibilities. These often include management of air quality, watersheds (including surface and subsurface hydrology, soils, geology, and climatic processes), fish and other aquatic biota, wildlife (including birds, mammals, insects, and other organisms), vegetation, fire, caves, grazing, mining and minerals, hazardous materials and toxic wastes, threatened and endangered species, non-native species, pests, backcountry and frontcountry visitor impacts, and impacts of park facilities.

In developing resource programs and assessing environmental effects of proposed facilities or management actions, it is imperative that resources be dealt with as *systems* of interrelated dynamic components. The challenge for resource managers is to maintain a professional level of expertise as well as knowledge of changing laws and policies over this wide range of subjects. In addition, they should stay abreast of new concepts and emerging fields such as conservation biology, restoration ecology, and behavior of pollutants in the environment. It is clear that we need to develop better ways to meet the need for expertise at the field level.

After we have hired well educated people and given them experience and training to broaden their knowl-

(Continued on page 9)

Professionalism

Other aspects of professionalism that time limitations did not allow the workshop to address adequately included:

Intake routes: Most intake positions are in fields other than resource management and do not necessarily select for qualifications needed in higher level positions. We need an established intake route and a mobility ladder, to insure bringing in qualified people.

Lack of applicants for GS-12s and above: High level resource management positions, particularly in central offices and remote locations, have had difficulty attracting well-qualified applicants. This may be due to the still small number of resource managers Servicewide or because of personal career preferences. There has been little opportunity for RMs in low- to mid-graded NPS RM positions to gain critical experience and training in supervision and program management.

Survey of White-tailed Deer Impacts

By Scott J. Miller, Susan P. Bratton, and John Hadidian

When many of the first NPS areas were designated, problems with ungulate browsing were rare. In the first decades of this century, ungulate populations, from overhunting and habitat loss, often were near their historic lows. In the case of white-tailed deer, hunting regulation, restocking, habitat improvement and protection, and succession on former agricultural lands, all have encouraged population increases. As a result, more and more NPS areas now are reporting concerns with deer impacts on park resources.

As part of a literature review project sponsored by the NPS National Capitol Region, researchers from the NPS/CPSU at U/GA, Athens, investigated the existing literature on white-tailed deer impacts on native vegetation. This project produced little data on such impacts on endangered plant species, so an attempt was made to gather more information. The investigators surveyed by telephone 173 scientists and natural resource managers, asking information such as field observations of deer disturbing endangered or threatened plant populations.

Included were resource managers from 76 NPS areas in the Southeast, Southwest, Midwest, National Capital, Middle Atlantic, North Atlantic and Rocky Mountain Regions, who had responsibilities for parks that might have significant white-tailed deer populations. Areas with limited acreage of forest or of native plant communities were excluded from the survey. The managers were asked if deer were known to disturb endangered flora, if they were influencing forest regeneration, causing a browse line, or depredating crop plants or ornamental species.

Survey Results

In comparison to informants from the Natural Heritage Inventory, NPS staff reported far fewer observations of deer grazing or damaging endangered species. Of the information received concerning rare plants, 60 percent was from the various state Natural Heritage programs, 6 percent from The Nature Conservancy land stewards, 6 percent from NPS resource managers, and 28 percent from experts affiliated with the USFS, USFWS, universities and other institutions.

The informants and literature search produced a list of 98 nationally or state listed or candidate endangered or threatened plant species disturbed by deer. Interestingly, 38.7 percent of these species belonged to either the lily or orchid families (*Lili*aceae or *Orchida*ceae). Sources of impact included not only grazing and browsing, but antler rubbing and trampling. A full report and species list from this part of the survey has been submitted to ***Natural Areas Journal*** and preliminary copies also are available from the authors (listed at the end of this article.)

Of the parks surveyed, 26 (34.2%) reported high deer populations having potentially adverse impacts on park resources (Table 1), whereas 50 parks (65.8%) reported no problems at the current time. Only 3 of the 26 parks (11.5%) had records of deer impacts on endangered or threatened flora, although some parks, such as Catoctin Mountain, expressed concerns for more than one species.

Of the parks with known impacts, 84.6 percent reported browse lines, 19.2 percent reported crop damage, 7.7 percent reported destruction of ornamentals, and 34.6 percent reported suppression of forest regeneration or seedling production (Table 1). Among reported problems were bark stripping from deciduous (*Ulmus* spp) trees at Catoctin Mountain Park, and a concern for grazing of *Platanthera* spp. populations. Apostle Islands National Lakeshore is experiencing a change in forest community structure and function due to intensive browsing. At Lincoln Boyhood National Memorial there are extreme problems of browse on red-stemmed dogwood (*Cornus stolonifera*) as well as newly planted seedlings of deciduous trees.

When Fort Necessity National Battlefield attempted to reestablish trees on part of the site, deer ate many of the newly planted seedlings. Cumberland Island National Seashore is experiencing suppression of live oak (*Quercus virginiana*) regeneration along with reduction of many native forest floor forb populations. Several historic parks, such as Gettysburg National Military Park, George Washington Birth Place, and Hopewell Furnace National Historic Site, are experiencing repeated damage to agricultural crops planted to maintain the historic scene.

The survey produced other patterns of interest in determining an overall NPS strategy for managing white-tailed deer. First, the 26 parks reporting impacts had a smaller average size (34,200 acres) than the 50 parks reporting no impacts (averaging 50,000 acres). Very large parks and, of course, very small parks, are less likely than "middle-sized" parks to have problems.

Second, of the 26 parks reporting deer impacts, 17 were national historic parks, battlefields, or monuments with an average size of 3,600 acres. Third, many of the parks reporting impacts have a high ratio of

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Table 1. U.S. national parks reporting impacts by white-tailed deer.

Park	State	Type of Vegetation Affected				
		E&T Plants	Ornamentals	Agricultural Crops	Seedling Reproduction	Browse Line
Antietam Natl Battlefield	MD			*		
Apostle Island Natl Lakeshore	WI				*	*
Blue Ridge Parkway	NC					*
Catoctin Mountain Park	MD	*			*	*
Chesapeake and Ohio Canal Natl Hist Park	MD				*	*
Chickamauga & Chattanooga Natl Milt Park	GA					*
Colonial Natl Hist Park	VA					*
Cumberland Island Natl Seashore	GA	?			*	*
Cuyahoga Valley Natl Recreation Area	OH					*
Eleanor Roosevelt Natl Hist Site	NY		*			
Fire Island Natl Seashore	NY					*
Fort Necessity Natl Battlefield	PA				*	*
George Washington Birth Place	VA			*		*
Gettysburg Natl Military Park	PA			*		*
Great Smoky Mountains Natl Park	TN	*			*	
Hopewell Furnace Natl Hist Site	PA			*	*	*
Horseshoe Bend Natl Military Park	AL					*
Lincoln Boyhood Natl Memorial	IN				*	*
Lower St. Croix Natl Scenic Riverway	WI					*
Lyndon B. Johnson Natl Hist Park	TX		*			*
Mammoth Cave Natl Park	KY					*
Morristown Natl Hist Park	NJ				*	*
Pea Ridge Natl Military Park	AR					*
Saratoga Natl Hist Park	NY					*
Valley Forge Natl Hist Park	PA			*		*
Wilson's Creek Natl Battlefield	MO	*				

Professionalism

(Continued from page 8)

edge beyond their education specialty, we need to maintain their professional expertise at the highest level possible. Resource managers should be encouraged to participate in activities such as short courses, scientific conferences, and graduate level continuing education opportunities. The NPS should regularly sponsor workshops specifically targeted toward resource managers, focusing on state of the art themes.

Natural and cultural resources, which form the foundation on which the National Park System is built, are facing threats as never before. Natural resource programs, including research and resource management, made up only 6 percent of the NPS budget in FY 1991. Whether or not the NPS considers its own resource managers to be professionals is projected to others by how the NPS is organized. Resource management must surface as a keystone responsibility, considered a part of "line management," with sufficient personnel and support to deal with the issues faced by the parks in today's world.

Jope is Regional Resource Management Specialist in the Pacific Northwest Region, Seattle, WA.

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Native Seed Bank Brooklyn Reclamation Project

By Carol A. Pollio and Walter H. Davidson

The 1977 Surface Mining Reclamation and Recovery Act (SMRCA) requires the reclamation of land disturbed by surface mining. This law also addresses the issue of areas mined prior to 1977, by establishing a fund to begin emergency reclamation of the most hazardous sites. Within New River Gorge National River, there are hundreds of such mine hazards eligible for abandoned mine land (AML) reclamation funding, and many others that, although not hazardous, need reclamation work. The site used for this study, the Brooklyn Mine Refuse Area, (BMRA), was considered a low priority for emergency funding because it was not a serious threat to health and safety or to the environment. The Brooklyn site created an aesthetic problem, however, because of its visibility from the river and the air.

The BMRA consists of a large, almost completely unvegetated mound of unstable refuse. The NPS has developed resource management guidelines that encourage the use of native species for revegation projects within natural zones. This project was developed in order to determine if the native seed bank technique would encourage natural succession to reclaim disturbed sites, allowing for increased stabilization, increased adaptation of plants to local climatic conditions, and at the same time, produce a source of food and shelter for wildlife.

Another consideration was the cost associated with assembling a native seed mixture from commercial sources. The native seed bank method uses local topsoil that already contains seeds of existing native plant communities. These seed banks are excellent sources of both primary and secondary succession species thought necessary to the development of natural ecosystems (Wade 1986).

Native seed banking is not a new technique. It has been used by a number of researchers since the mid 70s, at first in the arid western regions of the country, and more recently in the Appalachian Mountains of the eastern United States. Farmer, et. al. (1982) experimented with spreading Appalachian forest topsoils for reclamation, producing 134 taxa on two mine sites and

***Biological Technician** Judy Weese in 1st replication plot (June 1989). Photo by Carol A. Pollio*

one nursery site (Farmer et al 1982). This study, conducted in Tennessee, also concluded that a large amount of nitrogen and phosphorous was taken up by the plants growing in the native seed banks. These essential nutrients, they suggested, might be important in the development of later plant communities, possibly enhancing the diversity of species.

Objectives of this project were twofold. One was to encourage the emergence of native plant species in order to reclaim disturbed sites, such as minespoils. The second was to determine if seasonal variations would change the composition of plant species that emerged. Other considerations, though not specific objectives, were cost effectiveness and personnel time necessary for implementation of native seed banking for future reclamation projects.

Methods

In June of 1989, three 20' x 20'' experimental plots were delineated on the refuse pile at the Brooklyn site. During each phase of implementation, 3 additional plots were installed, creating a total of 12 experimental plots. Phases, or replications (Reps), were installed in June and October, 1989, and April and June, 1990.

Prior to installation of the plots, soil samples were taken from the project site and analyzed by the USDA Laboratory in Berea, KY. Soil analysis data were collected for six plots, two samples from the top and four samples from the slope of the spoil pile. Samples were tested for the following parameters: pH, Aluminum, PO_4, Sulphur, Total Carbon, Calcium, Magnesium, Potassium, Sodium, Barium, Silicon, Zinc, Phosphorous, Iron, Copper, Manganese, Cobalt, Nitrogen, Titanium, Chromium and Lead. This information was then compared to baseline soil composition data to determine the application rates of lime and fertilizer.

Each of the plots had a pH in the range of 3.5 to 4.8, or relatively acidic. Below a pH of 5.0, aluminum, iron and manganese often are soluble in sufficient quantities to be toxic to some plants (Brady 1971). Soil sample results showed high levels of aluminum and iron were present. Treatment with agricultural lime rated at 105 lbs/acre, equivalent to 600 lbs/acre, was performed as a site preparation to reduce the concentration of iron, aluminum and manganese in the experimental plots.

Plots also were pretreated with fertilizer, 100 lbs rated 10-20-20, equivalent to 40 lbs N, 80 lbs P and 80 lbs K per acre. The "native seed bank" material, the top 2 to 3 inches of forest floor and litter, was removed from preselected sites manually and distributed on the plots at approximately the same thickness. The availability of suitable borrow material in the area presented a problem and caused a difference in the soil used for each installation. The highest quality soil was used for the initial plots in June 1989, and suitable material of a lesser quality was used for all subsequent plots. The latter contained a higher percentage of coal refuse material and less organic material (visual observation). In spite of these limitations, all plots exhibited comparable growth of both woody and herbaceous species.

Measurements

Once the plots were installed, the emergence of

White-tailed Deer Impacts Surveyed *(Continued from page 9)*

boundary to interior area, with a majority of these also situated next to suburban, developed, or agricultural areas. And fourth, several of the natural areas reporting problems are either islands or have isolated deer populations without large predators (i.e. Apostle Islands and Cumberland Island).

Discussion

Surprisingly few NPS areas reported white-tailed deer impacts on endangered plant species. This may be due to one of several factors or a combination of them. First, very few moderately sized parks have formal endangered species monitoring programs, hence some deer impacts may not be noticed or documented. Second, the Heritage programs have far more field professionals with training in plant taxonomy and plant ecology than the NPS does. Thus, one might expect the Natural Heritage programs to have more sightings and information.

Third, since many of the parks with white-tailed deer concerns are historic, they may not support many rare plant populations within their boundaries. Although some historic areas, such as Chicamauga-Chattanooga National Military Park, contain regionally important rare plant habitat, NPS historic areas probably have fewer rare plants than the small, but botanically unique, Natural Heritage Conservation areas. The data do suggest, however, that all NPS areas with a potential for "overgrazing" by deer should have completed rare plant inventories and should have field monitoring established, especially for susceptible genera such as *Cypripedium* (lady slippers), *Trillium*, and *Platanthera* (habernarias or fringe-leaf orchids).

The survey results indicate a trend for smaller, historic parks and parks with a high boundary to interior ratio to have greater concerns for deer impacts. This suggests that the NPS tradition of concentrating major wildlife research efforts in the larger natural areas will fail to address properly the issues raised by white-tailed deer.

Further, many of the areas affected have no wildlife biologists or science staff of their own. Environmental conditions and management practices in areas outside the parks may have a major influence on deer impacts inside the parks. This makes NPS deer management extremely "political" because of the large number of sites involved, the influence of other agencies, and the visibility of the issues to the public. Some of the problems are specific to historic parks and districts (e.g. Gettysburg and Cades Cove), and may require management models not normally applied in natural areas.

To deal properly with the issues and problems generated by an increase in white-tailed deer populations in and around parks, it would be most effective to break with the NPS tradition of research and management programs localized in larger parks, and to deal with problems *interregionally*. Communication and cooperation, particularly among the four easternmost Regions, already are moving in this direction. However, the question remains as to how the NPS might best approach such a disperse resource management problem and objectively evaluate deer impacts on both native and cultivated flora.

Hadidian is a wildlife ecologist with the National Capitol Region's Center for Urban Ecology in Washington, DC; Miller and Bratton were with the NPS/CPSU at U/GA, Athens when this research was done; Bratton has since left the NPS to teach environmental ethics at Messiah College in Harrisburg, PA.

Brooklyn Project

(Cont. from p. 10)

***Range pole** in 1st replication plot. Photo by Carol A. Pollio*

herbaceous and woody plants was monitored by park staff. An initial inspection occurred in August, 1989. At that time, there was approximately 80 percent cover in Rep. 1, 50 percent cover in Rep. 2, and 70 percent cover in Rep. 3. Six woody and 13 herbaceous species were noted. Another inspection in November, 1989, indicated that germination was occurring in the October plots, however, the germinants were too small to identify. In August, 1990, the 12 plots were inventoried and the data recorded. The data represent two growing seasons for the June 1989 treatment and one growing season for all subsequent treatments.

Results

One of the objectives of this project was to determine the effectiveness of the native seed bank method to encourage the germination of native plant species. Of the 40 herbaceous species present, 10 were non-native or introduced species (25%). Of the 17 woody plants present, only 1, the Princess-tree or Paulownia, was a non-native. It was interesting to note that the Princess-tree (*Paulownia tomentosa*), considered a take over species, had apparently succumbed to competition. Significant numbers of Paulownia had been identified in several plots during the early part of the study, but very few were present during the inventory process. The herbaceous species present also were primarily shade intolerant species, which will more than likely disappear as woody species develop.

These data also were analyzed based on the time of year the plots were installed. The plot installed in October, 1989, appeared to exhibit more varied species diversity. It is also important to note that several interim species observed prior to the inventory, such as mayapple, are primarily forest floor species and did not survive due to intolerance. Woody species that emerged in the plots might possibly have come from the adjacent natural forest. White ash, yellow poplar, black birch, river birch and red maple are all present in the surrounding forest and, therefore, make it difficult to determine whether or not this seed came from the seed bank.

Although no statistical analysis was attempted because seed bank materials came from different borrow areas, results indicate that a great variety of viable seed was indeed present in the seed bank. Many of the herbaceous species may not persist because of their individual intolerances, however, their presence allows additional organic material to be available for the next generation of germinants.

There were 191 trees, 160 shrubs and vines, and over 1,981 herbaceous plants counted during the August 1990 inventory. Using a multiplier of 100 (the replicates are approximately 0.01 acres) and dividing by 12 (the number of replicates) gives a result of about 1,590 trees per acre, 1,330 shrubs and vines per acre, and 16,508 herbaceous plants per acre. In addition, during the inventory process, several species of wildlife were observed using the plots, namely Eastern box turtle, Northern fence lizard, and black rat snake.

Discussion

This study demonstrates that native materials can be established on abandoned deep mine refuse using the native seed bank technique. Germination of native species did occur, and in some cases, crowded out non-native species that appeared. The scarcity of quality topsoil in this area of the Appalachians did affect our ability to analyze the data statistically, however, it did prove that the native seed bank technique can be successful even with poor quality soil. For the first time in 40 years, there is vegetative cover on a virtually bare coal refuse pile. In addition, it was accomplished at minimal cost and with existing day labor, making this method more cost effective than other revegetation methods.

(For tables showing soil sample results, herbaceous plant species and distributions at 3 different times of year, woody plant species and distributions at 3 different times of year, and the names of all herbaceous and woody plants found at BMRA, contact the authors at New River Gorge National River, P.O. Drawer V, Oak Hill, WVA 25901; (304) 465-1447).)

Pollio is an NPS Resource Management Specialist at New River Gorge; Davidson is a Research Forester with the USDA, stationed at PA State University.

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Olympic NP Dams Update

By Cat Hoffman

The Federal Energy Regulatory Commission (FERC) is considering license applications for two dams on the Elwha River which supply power to a Japanese-owned paper company (Daishowa America, Inc.) in Port Angeles, WA. (***Park Science***, Fall 1989, p. 6) The Elwha is the largest watershed within Olympic NP and is one of few rivers outside Alaska that once supported all 5 species of Pacific salmon. The Glines Canyon Dam is within Olympic NP; the Elwha Dam is downstream from the park.

Both dams were built in the early 1900s without provisions for fish passage. In a river affording 75 miles of habitat to anadromous fish, these dams block upstream migration of salmon 5 miles from the river's mouth. Research has documented the use of anadromous fish on the Olympic Peninsula as a source of food by at least 22 species of birds and mammals, indicating effects of the loss of these fish on many other species in the food chain as well. With the loss of this source of nutrient enrichment, the entire Elwha ecosystem has been disrupted.

Three separate (but not independent) scenarios are in progress regarding this issue:

1. Jurisdiction determination: In April 1991, FERC issued a final order asserting jurisdiction over the Glines Canyon project. Petitions for review of this ruling have been submitted to the 9th Circuit Court by conservation groups and by the Dept. of Justice (representing the Dept. of Commerce and of the Interior). At issue is whether the Federal Power Act gives FERC authority to license (specifically, "relicense") a hydroproject within a national park, or whether Congress must determine who has authority over a project in these circumstances.

Interior's Assistant Solicitor has issued a finding that neither the NPS nor FERC has authority to license the Glines Canyon project, and that only Congress can provide specific authorization needed for continued operation of the dam. The GAO has issued a report supporting Interior's position that FERC has no authority within the park, but maintains that FERC does have jurisdiction to call for removal of the Glines Canyon dam. Lawyers involved in this case estimate 2 years minimum before a court decision regarding jurisdiction is reached.

2. FERC licensing proceedings: In February 1991, FERC released a Draft EIS (DEIS) regarding licensing of Elwha and Glines Canyon dams. The DEIS analyzes four alternatives: (1) retention of both dams, (2) removal of both dams, (3) retention of Elwha dam with removal of Glines Canyon dam, and (4) retention of Glines Canyon dam with removal of Elwha dam. No preferred alternative is indicated.

The DEIS states that the cost of power to Daishowa America will be the same whether the dams remain with the addition of fish passage facilities or whether the dams are removed. The Bonneville Power Administration has indicated it would provide replacement power to Daishowa America if the dams are removed. A final EIS, indicating a preferred alternative, is expected in early 1992.

3. Legislative activity: Staffs of Sens. Brock Adams (WA) and Bill Bradley (NJ; Chair of the Senate Subcommittee on Water and Power) are drafting legislation which, in effect, would resolve this issue through negotiated settlement. The legislation was expected to be in draft form by the first of January 1992.

Summary

Projections of the timing and nature of a final decision regarding these dams confound the best of agency fortune-tellers. Many of the parties involved in this issue regard a negotiated settlement as the most expedient means to an end that is satisfactory to all concerns and, without losing sight of the primary objective, as being the best solution for restoration of the Elwha ecosystem.

GIS Helps Shenandoah Conduct Viewshed Analysis

By Alison Teetor and David Haskell

A primary resource related value of Shenandoah NP is its spectacular views from overlooks along the Skyline Drive from Wilderness mountain peaks. Many of these views are dependent on the continuation of traditional land uses on properties located outside the park. Until recent years, much of the land adjacent to the park has been maintained in forest, agriculture, and pasture.

Development was slow to come to the Shenandoah Valley and the remote hollows of Rappanahock, Green, and Madison counties. With the 1980s came rapidly rising real estate prices in the suburbs of Washington, DC. Completion of Interstate 66 and the shift of populations farther West started a rapid change in land use from rural to an urban style of development. The sudden, unplanned growth of homes, shopping malls, and light industry threatens the integrity of the world famous Shenandoah views.

This alarming new trend prompted initiation of a park management effort, which has become known as the Related Lands Program. Local jurisdictions and private citizens can identify and protect portions of open space that will be mutually beneficial. One objective is to identify adjacent lands that represent or promote park values. Values include, but are not limited to, protecting scenic views, maintaining trail access, providing corridors for wildlife movement, protecting air quality, and assuring the viability of species biodiversity within the region.

One way to describe and evaluate the scenic quality of land outside the park boundary is to create an integral vista/visibility map. The map created for Shenandoah describes the number of times an area can be seen from overlooks along Skyline Drive and highly visited mountain peaks. This paper describes the procedures used in 1990 to create this map.

Methods

In 1978, a visual resource inventory was performed and a visibility map created for the 1980 General Management Plan (GMP) (Stutzman, 1978). In addition, an integral vista report was prepared by the Denver Service Center (DSC) that identified those views integral to visitor enjoyment of the park (Shaver, 1980). These two reports served as the basis for a 1990 update of the viewshed analysis for the park.

The 1980 visibility map was created by VIEW-IT, a computerized mapping program (Stutzman, 1978). Efforts were made to acquire the original data from the DSC, however they no longer were available. Since these data were not available in digital form, a new viewshed analysis was performed, using parameters similar to those used in creation of the first map.

Each of the 76 overlooks along Skyline Drive was visited and compass bearings were established for the maximum angles of the viewing area. The GIS software Geographic Resources Analysis Support System (GRASS) was used for computing which land areas are visible from each overlook based on elevation. The 1:250,000 scale Defence Mapping Agency (DMA) elevation data were used, providing a 50 meter cell resolution.

An outline or pattern of each viewing area was plotted on Potomac Appalachian Trail Conference (PATC) maps (1:62,500) and digitized, using d.digit. Each area was given the value of 1. Glos (a GRASS program) was performed on each overlook. This program calculates which areas can be seen from an overlook based on

(Continued on page 13)

Table 1. Amount of land area visible within 20 kilometers (12 miles) from overlooks and mountain summits in Shenandoah National Park, Virginia. 1990.

Class	Name	Percent	# Hectares	# Acres
0	Areas Not Visible	75.75	2,431,105	983,855
1	Areas Visible from 1	8.48	272,005	100,079
2	Areas Visible from 2	5.21	167,146	67,643
3	Areas Visible from 3	3.82	122,603	49,617
4	Areas Visible from 4	2.36	75,847	30,695
5	Areas Visible from 5	1.80	57,732	23,364
6	Areas Visible from 6	1.30	41,570	16,823
7	Areas Visible from 7	0.89	28,493	11,531
8	Areas Visible from 8	0.36	11,703	4,736
9	Areas Visible from 9	0.03	877	355
10	Areas Visible from 10	0.01	297	120
11	Areas Visible from 11	0.00	47	19
12	Areas Visible from 12	0.00	5	2
	Totals	100.00	3,209,430	1,298,839

Figure 1. Viewshed Analysis of Shenandoah National Park – OV

Park Science Index for Volume 11 (No. 1, 2, 3 & 4)

Beginning in this issue and henceforth in the first issue of each volume of **Park Science**, *the previous volume's contents will be indexed by title, by author, by keyword and by park. Indexes will be bound in the center of the issue for easy removal and filing.*

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Seattle, WA 98104

Shenandoah Viewshed Analysis (Continued from page 12)

Table 2. Percent of land visible from overlooks and mountain summits at various distances from the Park boundary. Shenandoah National Park, Virginia. 1990.

Class	Name	Percent			
		1.6 km	3.2 km	4.8 km	6.4 km
0	Areas Not Visible	50.10	38.29	31.76	30.15
1	Areas Visible from 1	24.48	21.85	19.96	14.81
2	Areas Visible from 2	11.39	13.10	13.61	14.96
3	Areas Visible from 3	6.01	10.86	11.96	12.35
4	Areas Visible from 4	3.32	5.67	6.79	9.06
5	Areas Visible from 5	1.88	5.06	7.28	6.60
6	Areas Visible from 6	1.55	2.22	5.06	5.27
7	Areas Visible from 7	0.66	1.23	2.73	4.61
8	Areas Visible from 8	0.62	1.69	0.77	2.07
9	Areas Visible from 9	0.00	0.01	0.05	0.04
10	Areas Visible from 10	0.00	0.01	0.04	0.06
11	Areas Visible from 11	0.00	0.00	0.00	0.03
12	Areas Visible from 12	0.00	0.00	0.00	0.00
	Totals	100.00	100.00	100.00	100.00

elevation. Each pattern developed in step one and the UTM coordinates of the center of the overlook were utilized in the equation. A maximum distance of 20 kilometers (12 miles) was used as the furthest point visible. Observer height was defined as 1.5 meters (5 feet).

The information is displayed in cell format. Each cell has a numeric value that describes the angle of view at which the area is visible. The angle of view is defined as the angle from the oberver's eye to an area on the ground. For example, the horizon would be at an angle of about 90, a point at the bottom of a steep slope might be 120 degrees. This concept is further described in Stutzman's report. The angle of view can be used to define the relative importance of the view. For this analysis, the angle of view was ignored and all angles were treated as equally important.

Next, each view was reclassified into two classes: a classification of "1" indicating areas visible, and a "0" indicating areas not visible. Appendix A of Stutzman describes the view angles, center point, and GRASS files used to delineate each view. Seventy-six overlooks and four mountain summits or trail destinations were described in this manner.

Thirteen overlooks and four trail destination vistas were defined as integral or encompassing the overall viewing experience of the park. In 1980, photographs showing the panorama of these views were taken to document the scene at that time. These were included in the integral vista report. In an effort to describe changes over time, photos were taken again in 1990, using the parameters outlined in the original report. In addition, these integral views were used in the compilation of the visibility map (Fig. 1).

In order to create a visibility map detailing areas of land seen from multiple views, individual views were combined, using Gmapcalc. Each of the resulting integral vistas was then added, and together they created a composite map showing areas visible from multiple overlooks.

Results and Discussion

Land areas were visible from 1 to 12 overlooks (Table 1). The amount of land within 1.6 (1 mile), 3.2 (2 miles), 4.8 (3 miles), 6.4 (4 miles), and 20 kilometers (12 miles) of the park visible in each class is outlined in Table 2. Ninety-seven percent of the areas were visible from 0 to 7 overlooks. Most of the areas seen from great than 7 overlooks occur further than 6.4 kilometers (4 miles) from the park boundary. Distance from the park can be an important consideration when evaluating the relative importance of land outside the park.

Another factor to be considered is whether or not an individual view is more "valuable" (scenic, unique) than another. The integral vista assessment was used as a guide to the relative importance of specific views.

Conclusion

The viewshed analysis and production of a visibility map were created to help park managers identify which land areas outside the park are significant in terms of scenic values. The map is intended to be used as a screening tool. Areas of particular interest will be visited to verify the map projections. Information concerning which views overlook a particular parcel can be determined from the pattern files. Photographs of each integral vista will be maintained every 10 years to document changes in scenery and the areas visible over time.

The viewshed map already is being used extensively in the park's Related Lands Program. For example, it was used to determine which of several alternative new land fill sites in an adjoining county would be the least visible from key park viewpoints. The park recommendation was used by the county planner to make the final determination for the site.

Haskell is Chief, Division of Natural Resources and Science at Shenandoah NP; Teetor is a GIS Specialist, formerly with the park.

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Shaver, David. 1980. Identification of Integral Vistas. Unpubl. NPS Report. 80 pp.

Stutzman, Susan. 1978. Using Field Surveys and Computer Techniques: A Visual Resource Inventory for Shenandoah NP. Denver Service Center. Unpubl. NPS Report. 16 pp.

Yellowstone Northern Range Study Finds No Negative Impacts

A 5-year study by 33 scientists representing 3 federal agencies and 12 universities was released by Yellowstone NP in November 1991; the findings showed no negative impacts of native ungulates in grasslands and in the majority of shrublands in the park's northern range. Reaction, as mirrored in the public press, found the report to be highly controversial.

An article by Francis J. Singer, Yellowstone research scientist and one of the report's authors, will be carried in the Spring issue of ***Park Science.***

NPs Participate in Statewide Effort Against Alien Pests

Haleakala NP, having recently successfully fended off an invasion of rabbits, has come to the realization that the park cannot afford to wait until aggressive alien invaders arrive within park boundaries before taking action. The park is actively involved in an embryonic outreach campaign against a number of incipient plant invaders on Maui, including *Miconiacalvescens*, *Cyatheacooperi*, *Cortaderiajubata*, *Pennisetumsetaceum*, and *Verbascumthapsus*. We are particularly delighted, therefore, to have participated from an early stage in a project that may well prove to be a landmark among efforts to protect Hawaii's natural areas from the onslaught of alien invaders.

Along with Hawaii Volcanoes NP, Haleakala is an active participant in a statewide effort, coordinated by The Nature Conservancy of Hawaii and the Natural Resources Defense Council, to reduce the flow of alien pest species becoming established in Hawaii. Other participants include the Hawaii Department of Agriculture (HDOA) Plant Quarantine Branch; HDOA Plant Pest Control Branch; HDOA Animal Industry Division, Inspection and Quarantine Branch; the Hawaii Department of Land and Natural Resources (HDLNR) Division of Forestry and Wildlife; HDLNR Division of Aquatic Resources; the Hawaii Department of Health, Environmental Services Division, Vector Control Branch; the U.S. Customs Service; the U.S. Army, Pacific Command; the U.S. Postal Service; the U.S. Forest Service; the U.S. Fish and Wildlife Service, Enforcement Division; the USDA Animal and Plant Health Inspection Service, and the Hawaii Sugar Planters Association.

The need for coordination and cooperation among such a diverse array of players is obvious, in view of what is at stake!

A well-attended workshop, held in Honolulu on Oct. 1, 1991, was successful in identifying the major areas where "the system" can be tightened. For national Parks, one of the highest priorities is for increased effectiveness of "the system" in rapidly eradicating newly reported alien species before they become established.

This can best be done through improved communication and coordination among agencies, through at least modestly increased funding for the lead agencies, and through tightening pertinent legislation and rules. Other very high priorities include fostering of public understanding and cooperation through education, and changing the law to allow for inspection of first class mail for illegal entry of prohibited alien pests.

We hope to establish a small working subgroup on Maui to deal with local alien pest eradication efforts at a grassroots level.

Lloyd Loope, Research Scientist,
Haleakala NP
Donald Reeser, Superintendent,
Haleakala NP

Southeast Region

Dr. Caroline Rogers, Research Biologist at Virgin Islands NP, was an invited participant in the National Forum on Ocean Conservation, sponsored by the Smithsonian and NOAA and held in Washington, DC, Nov. 19-21, 1991. Rogers presented a paper on the effects of sedimentation on coral reefs. She went from there to Martinique for a meeting on "Ecology and Management of Coastal Areas in the Wider Caribbean," sponsored by UNEP and co-organized by the Conseil Regional de la Martinique and the Universite des Antilles et de la Guyane. There, she spoke on "Protected areas and coastal management: the case of Virgin Islands NP and Biosphere Reserve."

* * *

Assateague Island National Seashore recently hosted its second science conference; 21 researchers presented findings to an audience of 150, many of whom were part of the first such conference in 1987. Presenters represented 9 universities and colleges and 5 state and federal agencies. Two thirds of the funds for Assateague's resource management program in 1991 came from sources other than the national seashore's operating budget.

Pacific Northwest

A year-long process to develop a management plan and EIS for mountain goats on the Olympic Peninsula was announced on Oct. 31, 1991 by Olympic NP, Olympic NF, and the Washington Department of Wildlife. An interagency team has been appointed to develop a plan balancing the mandates and objectives of each agency, the preservation of fragile alpine ecosystems, and the concerns of the public.

Olympic NP has been working actively on the mountain goat problem within the park for more than 10 years. Recognizing potential effects from mountain goats on rare plants within forest wilderness areas, Olympic NF has joined the planning effort. The Wash. Dept. of Wildlife, as manager of wildlife within the national forest, is a cooperating agency. Scoping meetings for preparation of the plan and EIS will begin in January 1992. The management plan and final EIS are slated for completion in spring 1993.

* * *

Steve Gibbons, Natural Resource Specialist for the PN Region, attended a 2-day workshop on "Biology and Management of Wild, Edible Mushrooms in Pacific Northwest Ecosystems" on Oct. 29-30, 1991 in Eugene, OR. Co-sponsors were the Willamette NF, the Pacific Northwest Research Station, Oregon State University, and the Washington Dept. of Natural Resources. Participants (270 of them) represented the commercial mushroom industry, mycological societies, state and federal agencies, the scientific community and the NPS.

Objectives of the workshop were to educate resource managers on the basic ecology of fungi in forest ecosystems, characterize the major edible species with commercial implications, discuss current regulations and concerns regarding commercial harvest, and provide a forum to develop regional consensus for managing and monitoring this resource.

For more information on this workshop and its applicability to resource management and protection of wild edible fungi in the PNR, contact Gibbons in Seattle, WA at (206) 553-5670 or FTS 399-5670.

***Ted Fremd, paleontologist** at John Day Fossil Beds National Monument in Eastern Oregon, scrutinizes a hillside near the burial site of "Ellen the rhino," (described in the Fall 1991 issue's Regional Highlights). The rhino* (Rhinocerotidae Diceratherium armatum), *who died nearly 25 million years ago, had the largest skull known – almost 2 feet from nose to neck. Photo by Ellen Morris Bishop, courtesy of The Oregonian, Portland.*

* * *

A gray wolf, listed by the USFWS as an endangered species, was sighted last summer in the Hozomeen area of Ross Lake National Recreation Area, first by a park archaeologist and later by a park biologist and several park rangers. The visual sighting, photographs and tracks provided undisputed evidence that the animal is a gray wolf. In 1990 a wolf was sighted in late May and vocal responses from 2 adults and several pups indicated an active den in the same approximate area. The den location was never found.

Hozomeen is at the north end of Ross Lake on the US/Canada border, approximately 40 miles south of the town of Hope, BC. The lucky "sighters" included Park Geologist Jon Riedel (into whose camp the gray wolf entered and passed within 15 feet of him), Chief Ranger Dave Spirtes, Park Biologist Bob Kuntz, and WA/Dept. of Wildlife biologists Jon Almack and Scott Fitkin.

Western Region

Fifty-eight authors presented 65 papers and posters to more than 120 participants at the Fourth Biennial Conference on Research in California's National Parks Sept. 10-12, 1991. Sequoia-Kings Canyon was the subject of 15 presentations, Channel Islands and Redwood followed with 10 each. Award for the best presentation went to Dr. Jim Gramann of Texas A&M. In his plenary session, "Contributions of Sociology to the NPS," Gramann used the visitor survey work in progress at Yosemite to demonstrate the types and complexities of sociological studies available to park managers.

Papers are being reviewed and a conference Proceedings is slated for early 1992. Meanwhile, CPSU Leader Stephen D. Veirs, Jr., at U/CA/Davis, has produced a 50-page program with 63 abstracts, available from the NPS/CPSU, Institute of Ecology, U/CA/Davis, (916) 752-3026.

* * *

The CPSU at U/AZ, Tucson, has published, as a supplement to a 1988 publication, the following:

Nagel, Carlos. *Report on Treaties, Agreements, and Accords Affecting Natural Resource Management at Oregan Pipe Cactus National Monument*, 1991. Special Report No. 8 (Supplement).

In June 1991, ***Wilson Bulletin,*** 103(2), 1991, pp 309-310, published the following:

Kunzmann, Michael R. and R. Roy Johnson (with the U/AZ NPS/CPSU). *Unusual Behavior in a Solitary Vireo.*

Copies of these papers may be had from the NPS/CPSU, 125 Biological Sciences (East) Bldg. 43, U/AZ, Tucson 85721.

* * *

Gary Fellers, Research Biologist at Point Reyes National Seashore, and Charles Drost have published a monograph, "Ecology of the Island Night Lizard, *Xantusia riversiana*, on Santa Barbara Island, CA" in *Herpetological Monographs*. In spite of their federal

***Endangered gray wolf** is caught by the camera in the Hozomeen area of Ross Lake National Recreation Area. The gray wolf resembles a large domestic dog but has longer legs, larger feet, and a narrower chest.*

status as a threatened species, island night lizards were quite abundant in some Santa Barbara Island habitats and clearly not in need of federal protection. In spite of their common name, night lizards were found to be strictly diurnal.

Drost and Fellers also published a paper on "Density cycles in an island population of deer mice, *Peromyscus maniculatus*, in *Oikos*. Though mainland deer mice have rather stable population levels, deer mice on Santa Barbara Island (Channel Islands NP) have distinct population fluctuations that have ranged from 2 to 462 mice/ha. Deer mice play a large part in the ecological workings of Santa Barbara Island. Due to their abundance, their position as both first and second level consumers, and their importance as a prey species, deer mice are one of the most important components of the simplified terrestrial ecosystem. Changes in deer mouse populations affect a variety of plant species, terrestrial invertebrates, the hawks and owls, and even some of the seabirds.

Fellers presented an invited paper for the American Society of Ichthyologists and Herpetologists at the American Museum of Natural History in New York last June. His paper, "Conservation Biology of an Abundant Lizard, *Xantusia riversiana*," was part of the symposium, "Strategies and Programs for the Conservation of Biodiversity."

Alaska Region

Two new Resource Management Specialists welcomed to the Region are Rick Potts (Katmai NP) and Patty Rost (Gates of the Arctic NP). Two Resource Management position vacancies exist at Yukon-Charley Rivers NP and Lake Clark NP.

* * *

Dale Taylor, Jeanne Schaaf, Paul Haertel, Rich Giamberdine, Sean Bursel, and Leslie Star-Hart were in Providenyia, Chukotka attending a conference in on the Beringian International Park when the Soviet coup attempt occurred. Concern over the event was lightened by the Soviets in attendance, who requested the US to make Chukotka the 51st United State.

* * *

The Alaska Region's Global Change program, USGS, US Army Corps of Engineers Cold Regions Research and Engineering Lab, and the U/AK Geophysical Institute co-sponsored a glacier research workshop in 1991, report copies of which are now available from Dale Taylor, Regional Headquarters in Anchorage (907)257-2568. Goal of the workshop was to promote cooperation among scientists involved in glacier research and land managers. Participants included 16 parks, 8 from Alaska and 8 from the lower 48. The report contains recommendations.

* * *

Carol McIntyre, a wildlife biologist temporary with ARO, presented a paper and chaired a session of the Raptor Research Foundation Annual Meeting in Tulsa, OK in November 1991. The paper, "Using satellite radio-telemetry to track local and long distance movements of an Alaskan golden eagle," reported on a pilot effort to use the technology to determine migration and wintering areas of golden eagles from Denali NP and Preserve.

In August 1990, McIntyre fitted a nestling golden eagle with a prototype satellite transmitter and was able to track the eagle from Denali to its wintering ground in northern Idaho. McIntyre has been researching golden eagles in Denali, as well as other raptors in Alaska, for the last 5 years. She is completing an MS at U/AK-Fairbanks; her thesis is on "Breeding biology of golden eagles in Denali NP."

* * *

Layne Adams, ARO Wildlife Research Biologist, presented a paper at the First Arctic Ungulate Conference in Nuuk, Greenland Sept. 3-8, 1991. The conference combined the International Muskox Symposium and International Reindeer/Caribou Symposium and was attended by 120 from North America, Scandanavia, and the Soviet Union. Adams' paper, "Relationships between calf sex ratio and birth date in the Denali caribou herd," described variation in calf sex ratio *within* the calving period (calves born during the peak of calving are predominantly female), the population effects of that variation, and a possible behavioral mechanism that could lead to the observed sex ratios.

Adams has been conducting research on population dynamics of the Denali caribou herd, which is the only naturally regulated barrenground caribou herd in North America.

Butterfly Habitat Restoration

Laura Nelson and Terri Thomas, Natural Resource Specialists at Golden Gate NRA, report a pilot stody to assess the effectiveness of revegetating coastal grassland and scrub habitat of 2 federally listed endangered species – the Mission Blue and the Blue Elfin butterflies. Their habitat has been reduced by urbanization of the San Francisco Bay area and disturbed by introduction of invasive exotic plants. Revegetation efforts in the GGNRA include removal of approximately 100 acres each of frech broom and pampas grass, using manual pulling and cutting, herbicide, or heavy equipment.

At Milatra Ridge, San Mateo County, 6 experimental seeding and planting treatment plots were established in 1988 following removal of pampas grass by heavy equipment. The plots were monitored in the summers of 1989 and 1991. Treatments included different combinations of hand-broadcast seeding with locally collected natives, hydroseeding with commercial native grasses, and transplanting native seedlings grown in a nursery. To sample the vegetation cover, both point and quadrat methods were used.

The point method gave a more accurate representation of the plant species present. A mix containing seeds collected from native plants in the immediate vicinity, hand broadcast and raked in, resulted in the greatest overall coverage by natives after 2 years, and the least amount of invasion by nonnative forbs. Results of this pilot study will provide park resource managers with preliminary information needed to conduct a 3-year restoration effort leading to long-term management of the community and recovery of the endangered butterflies.

Recent publications by AK Region personnel include:

Wesser, S.D. and W.S. Armbruster. 1991. "Species distribution controls across a forest-steppe transition: a causal model and experimental test." *Ecological Monographs* 61:323-342.

Rocky Mountain Region

The only wild population of black-footed ferrets in the world was established in the Shirley Basin of Wyoming last summer when about 50 ferrets were released from a captive population. This was the first of several planned releases in the recovery program for the species. The next release is scheduled for the summer of 1992 in northern Montana followed by a proposed release in 1993 in Badlands NP. The last known wild ferrets were discovered and captured a few years ago in western Wyoming, sometime after it was thought the species was extinct.

* * *

The FWS has published a proposed rule to list the Mexican spotted owl as a threatened species (Fed. Reg. Vol. 56 No. 213, 11/4/91). RMR parks participated in the status review for the subspecies and have been conducting spotted owl surveys for several years. Zion NP completed a third year of Mexican spotted owl surveys in 1991 (funded by the RMR). Twenty-one birds representing at least 8 pairs of spotted owls were observed. Owl pairs reared at least 7 young in Zion NP this season. Limited surveys revealed at least 5 spotted owls in Capitol Reef NP, 2 owls in Canyonlands NP, and 2 owls in Glen Canyon NRA.

Work by the USFS and park staff revealed a nesting pair of spotted owls that successfully reared young in Mesa Verde NP. A home range and habitat use study of Mexican spotted owls on the Colorado Plateau was begun this season. This is an interagency project involving the FWS, BLM, the State of Utah and NPS. The project is being conducted by Charles van Riper and David Willey out of the CPSU at Northern Arizona Univ. Park and RMR staff are participating in interagency efforts to coordinate management, surveys and research on the subspecies. Mike Britten of the RMRO is coordinating spotted owl work in the Region.

* * *

The RMR has completed 3 years of intensive fieldwork towards the recovery of peregrine falcon populations. Survey efforts in 1991 documented breeding peregrine falcons in 15 park areas, including 60+ territories in Glen Canyon NRA, 11 each in Dinosaur NM and Zion NP, 7 in Yellowstone NP, 6 each in Capitol Reef NP and Canyonlands NP, and 4 in Bryce Canyon NP. The NPS supported a final release effort (5 birds successfully released) of captive reared young peregrines in Bighorn Canyon NRA. At least one adult peregrine was sighted in Bighorn Canyon this past summer.

Glacier NP, where peregrines once nested, had several encouraging but unconfirmed observations made by visitors this season. The Recovery Team is currently working on an Addendum to the Rocky Mountain/Southwest Peregrine Falcon Recovery Plan to reclassify the species to reflect this peregrine population explosion.

The peregrine falcon program at Black Canyon of the Gunnison NM is typical of smaller park units in the RMR. In 1991 surveys in the NM revealed 2 nesting pair

(Continued on page 16)

information crossfile

"The Yellowstone Vision: An Experiment That Failed or a Vote for Posterity?" is the title of a paper by Yellowstone Supt. Bob Barbee, Biologist John Varley, and author Paul Schullery, from the Proceedings of a conference on "Partnership in Parks and Preservation," held in Albany, NY Sept. 9-12, 1991. In it, the authors describe a document created by the Greater Yellowstone Coordinating Committee – an overarching statement of principles that would guide future coordination among the many natural resource management agencies operating in the Greater Yellowstone Area. The document was called *Vision for the Future, A Framework for Coordination in the Greater Yellowstone Area*.

The paper describes how the document took shape, why it was attempted, and its stormy greeting from emotional and misinformed commodity groups (who termed it "a giant land-grab, another Federal lockup") and from the conservation community (who felt it didn't go far enough and who failed to come together in its defense).

They observe that "the American public, the owners of the parks and forests of the greater Yellowstone area, played virtually no role at all ... So we were faced with a powerful regional campaign, superbly engineered by special interest groups and featuring stunning inflammatory rhetoric against the *Vision*. We failed to convincingly invite the pro-*Vision* interests to mobilize adequately."

They conclude that "bureaucracies are put in place to police the status quo" and add: "Perhaps the foremost lesson we learned, at least so far, is this: before you undertake a project of this magnitude, be absolutely certain that your own leadership is prepared to give you full support, as far up the chain of command as imaginable."

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A $4.6 million study underway in southern Oregon has scientists from BLM and Oregon State University inquiring into the possiblity of logging in northern spotted owl habitat without destroying the habitat. Researchers will take detailed measurements of existing stands to identify what makes them attractive to owls, develop logging methods to reproduce those characteristics, and devise computer models to estimate timber yields. The study will be conducted over the next 10 years in the BLM's Medford District, neighboring private lands, and much of the Rogue River and Siskiyou national forests – an area covering about 3 million acres that is home to about 450 pairs of spotted owls. The study area has been logged over for decades, leaving a patchwork of clearcuts, partial cuts. old growth, and second growth that also has been shaped by fires, windstorms, and insect infestations.

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How Earth's biota will respond to the next major (possibly anthropogenically induced) environmental change can be predicted best on the basis of the fossil record, according to Scott Elias, a research associate at the Institute of Arctic and Alpine Research, U/CO, Boulder. Elias's article in ***BioScience*** (Sept. 1991, pp 552-559) examines the insect fossil record of the Rocky Mountains and finds that changes in insect distribution have taken place in a relatively short time, indicating that insect species are extremely mobile and able to move great distances to satisfy their ecological requirements in the face of changing climates.

"These distribution changes also suggest that the current insect communities of the Rocky Mountain region are simply the latest reshuffling of species," Elias notes, "and that insect species composition is probably in a more-or-less continuous state of flux." Elias suggests that the fossil record "forces us to ask ourselves how much we really know about rates of speciation" and related questions such as how long a population must be geographically isolated before it diverges from the species' gene pool.

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The Sept. 6, 1991 issue of ***Science*** (pp.1099-1104) contains an article by Geerat J. Vermeij (U/CA-Davis Geol. Dept) entitled "When Biotas Meet: Understanding Biotic Interchange." The author looks at the history of biotic interchange over the past 25 million years – what happens when a barrier separating two biotas with long independent histories breaks down and species from the "donor biota" invade the "recipient biota." He then looks at the "unprecedented scale" with which barriers are being breached in the human-dominated biosphere – both deliberately and accidentally, and reaches three tentative conclusions: (1) that many episodes of interchange are strongly asymmetrical; (2) biotas providing the bulk of invading species in asymmetrical interchanges contain species that have evolved high competitive, defensive, and reproductive performance in comparison with native species in the recipient biotas, and (3) biotas in which the magnitude of extinction before the onset of interchange was high are especially vulnerable to invasion.

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Laboratory exposure of bivalve molluscs (*Mercenaria mercenaria L.*) for 48 hours to 9 parent polynuclear aromatic hydrocarbons (PAHs) found in waste crankcase oil and analyzed over a 45-day depuration (cleansing) period found that the activated carbon filtration aquaria system did not depurate PAHs, but rather maintained them at detectable levels. The research, reported by NPS Ecologist John T. Tanacredi (Gateway NRA) and Raul R. Cardenas (Brooklyn's Polytechnic University) appears in ***Environ. Scie. Technol.*** 1991, 25, 1453-1461. The authors conclude that consumers of bivalve molluscs chronically exposed to persistent levels of PAHs in urban estuaries may be at higher than normal health risk. They recommend reevaluation of clam relay programs in urbanized estuarine systems and further research in this area.

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"Interdisciplinary Research in Historic Landscape Management" is the title of a supplement to Vol. 14: No. 6 of the ***CRM Bulletin***, cultural resource management information bulletin published by NPS. Gerald Kelso, a supervisory archeologist in the NPS North Atlantic Regional Office, describes the principles and techniques (still evolving) for identifying, evaluating, and preserving the vegetation of historic landscapes, and uses the knowledge thus gained to reconstruct the

regional highlights

(Continued from page 15)

occupying historic territories on the "Painted Wall" and near "Red Rock Canyon"; 6 peregrine chicks fledged from the 2 eyries.

* * *

The RMR is conducting a Bighorn Sheep Initiative with the primary goal of re-establishing the bighorn to 18 National Parks, Monuments and Recreation Areas. Seven scientific committees made up of conservation biologists, population ecologists, veterinarians, and bighorn sheep experts are conducting a problem analysis for the involved park areas. Look for a ***Park Science*** article on the Initiative. Frank Singer, currently at Colorado State University, is coordinating the project.

* * *

In late August 1991, Yellowstone NP hosted three visiting scientists from Russia as part of their 3-week tour of the Greater Yellowstone and Northern Continental Divide Ecosystems. The scientists were invited by the Interagency Grizzly Bear Committee to view occupied grizzly bear habitat and discuss with NPS, state, and USFS biologists techniques for managing bear-human conflicts. Despite the fact that their day in Yellowstone coincided with the beginning of the aborted coup attempt in the USSR, the scientists had a successful visit and were lucky enough to observe a grizzly bear sow with cubs in the park.

Grizzly bear reproduction exceeded target goals again in 1991 for the greater Yellowstone area. In 1990 a record number of cubs was observed in the GYA; 23 sows produced 57 cubs, including one litter of 4. The recovery goal is to average 15 sows with "cubs of the year." In 1991, 24 sows were observed with 43 cubs of the year. These higher figures could represent increased reproduction in the population, or they could mirror an increased effort to observe sows with cubs.

Mid-Atlantic Region

Three new resource management personnel have joined the Region's staff. Dave Reynolds has assumed duties as Regional Resource Management Specialist in Philadelphia, Hank Snyder is the new Supervisory Natural Resource Specialist at Shenandoah NP, and Julie Thomas is Shenandoah's new Air Quality Program Manager. Reynolds comes from the International Affairs office in Washington, where he was detailed to the Peace Corps and before that he served as Resource Management Specialist at New River Gorge; Snyder was previously at George Washington Parkway; Thomas was Regional Air Quality coordinator for the Southeast Regional Office.

* * *

Delaware Water Gap NRA, the USFS, EPA, and Delaware River Basin Commission co-sponsored a conference on Sustainable Wastewater Management, addressing different wastewater treatment methods and how they affect the hydrology and water quality of a watershed. The conference also examined the new water quality regulations for the Delaware River and how they will impact regional wastewater treatment.

* * *

Researchers at New River Gorge NR have identified a new state-listed rare species in an abandoned mine that was about to be sealed by the state. A population of the cave salamander (*Eurycea lucifuga*) will necessitate a revision of the state's plans.

information crossfile

behaviors and guess at the attitudes behind the behaviors of the people who made up the early industrial inhabitants of what is now Lowell National Historical Park and environs.

⁂

Climatically sensitive huon pine tree-ring chronology from western Tasmania is used by 8 authors to draw inferences about Austral summer temperature change since A.D. 900 and reported on pages 1266-8 in ***Science***, Vol. 253. Since 1965, huon pine growth was found to have been unusually rapid for trees that are in many cases over 700 years old. This growth increase correlates well with recent anomalous warming in Tasmania on the basis of instrumental records and supports claims that a climatic change, perhaps influenced by greenhouse gases, is in progress.

⁂

An informal survey to determine what information is now available on the extent, character, and management of old-growth forests on NPS lands has resulted in a 54-page report (Great Lakes CPSU Report 91-1) published in October 1991 by the Great Lakes CPSU at U/WI-Madison. Responses to a 1988 questionnaire from all 58 NPS units containing this community type found more than 4,867,800 acres, located in 32 states and the District of Columbia and in all 10 NPS regions.

Species listed for old-growth stands are available for vascular plants in 53 percent of the units and for birds in 35 percent. Many units (35%) had no information on which species are strongly associated with old-growth. Most frequently reported disturbances were logging, wildfire, windthrow events, and fire suppression. More than half (54%) of the units reported no management plan specific to old-growth forests. Research efforts in these forests included current research projects (60% of the NPS units), long-term data sets (63%), and permanent plots (35%).

⁂

Two related articles, attesting to the continuing worldwide interest in declining amphibian populations, appeared in the Aug. 23, 1991 ***Science***. One, by David Wake of U/CA's Museum of Vertebrate Zoology, maintains that scientific study of amphibians holds promise for a deeper understanding of the resilience as well as the limits of environments. Noting that modern amphibians have been on this planet for well over 100 million years, and thus could fairly be classed as "survivors," Wake suggests that "amphibians may serve usefully as bioindicators, organisms that convey information on the state of health of environments. How we read the message, and what to do about it, are timely challenges to scientists and to the public.

The companion article by Joseph H.K. Pechmann et al, deals with the problem of separating human impacts from natural fluctuations and concludes that distinguishing between natural population fluctuations and declines with anthropogenic causes may require long-term studies.

⁂

According to the Florida DNR's quarterly, ***Resource Management Notes***, wetland losses for states in the South Atlantic area are: West Virginia (-24%), Virginia (-42%), North Carolina (-49%), South Carolina (-27%), Georgia (-23%), and Florida (-46%). Approximately 28.7 million acres of wetlands are in these six states, which represent 27% of the total wetlands in the conterminous U.S. Overall, we have lost around 40% of the wetlands in the south Atlantic area. The source is the Society of Wetlands Scientists, South Atlantic Chapter Newsletter, June 1991.

⁂

A Department of the Interior pamphlet entitled *Wetland Activities* describes wetlands, why they are important, the President's goal for wetlands, and Interior agencies' wetlands programs (Fish and Wildlife Service, Bureau of Land Management, Bureau of Reclamation, Geological Survey, Bureau of Mines, Office of Surface Mining, Minerals Management Service, National Park Service, and Bureau of Indian Affairs).

For copies of the pamphlet and additional information, write WETLANDS, Mail Stop 6217 Main Interior Bldg., U.S. Dept. of the Interior, 1849 C St., NW, Washington, DC 20240.

⁂

A thorough (and thoroughly accessible) look at the links between land and water is provided in "An Ecosystem Perspective of Riparian Zones" in ***BioScience***, Sept. 1991, pp 540-551. Two stream ecologists (Stan Gregory of Oregon State U and Ken Cummins of U/Pittsburgh), a geologist (Fred Swanson with the USFS Research lab in Corvallis, OR) and a plant ecologist (Art McKee of OSU) propose a conceptual model of riparian zones that integrates the physical processes that shape valley-floor landscapes, the succession of terrestrial plant communities on these geomorphic surfaces, the formation of habitat, and the production of nutritional resources for aquatic ecosystems. Charts, graphs, and tables extend this concept through time and space and provide understanding of the wide array of ecological processes and communities associated with the land-water interface.

⁂

Helping Nature Heal: An Introduction to Environmental Restoration is the title of A Whole Earth Catalog/Ten Speed Press publication (Box 7123, Berkeley, CA 94707, $14.95) edited by Richard Nilsen and featuring theory of environmental restoration, how it is practiced the USA and around the world, and what is needed to jump start it anywhere. Barry Lopez's Foreword is a call to arms, bringing to mind an Information Crossfile piece that got "bumped" several issues ago. It quoted Frank Press, president of the U.S. National Academy of Sciences, who told an international meeting of the Group of Seven industrial nations in Paris in mid-1987: "What we are doing to the Earth's atmosphere, to the blue planet on which we live, is not merely ominous. It may already be beyond correction."

meetings of interest

1992

Jan. 21-23, FIRE IN PACIFIC NORTHWEST ECOSYSTEMS: EXPLORING EMERGING ISSUES, at Red Lion Hotel, Portland, OR, featuring 40 regional and national experts on various aspects of wildfire presenting state-of-the-art information on historical and ecological aspects of fire and its use to achieve management objectives. Contact Conference Assistant, College of Forestry, Oregon State U, Corvallis, OR 97331; (503) 737-2329.

Feb. 10-21, FOURTH WORLD PARKS CONGRESS, in Caracas, Venezuela; a technical, invitational, working meeting of leading world authorities on protected area management, sponsored by the IUCN and co-sponsored by UN agencies, governments, and national agencies including the NPS.

Feb. 19-22, SOCIAL ASPECTS AND RECREATION RESEARCH SYMPOSIUM, Theme: "Social Aspects of the Wildland/Urban Interface," at the Clarion Hotel, Ontario, CA. Contact: Debbie Chavez, USDA Forest Service, 4955 Canyon Crest Dr., Riverside, CA 92507.

Feb. 24-28, NINTH INTERNATIONAL CONFERENCE ON BEAR RESEARCH AND MANAGEMENT, Holiday Inn Parkside, Missoula, MT. Contact: James Claar, USFS Northern Region, PO Box 7669, Missoula, MT 59807 (406) 329-3288.

Mar. 4-6, HIGH ALTITUDE REVEGETATION WORKSHOP, University Park Holiday Inn, Fort Collins, CO; a biennial forum for discussion of the technology and unique environmental issues pertaining to reveg and rehab of disturbed lands at high elevations. Contact: Gary L. Thor, Dept. of Agronomy, CO/State/U, Fort Collins, CO 80523 (303) 491-7296.

Mar. 9-12, BIODIVERSITY TRAINING COURSE, in Tucson, AZ; (see article elsewhere on this page). Contact: Charles Pregler, BLM Training Center, 5050 N. 19th Ave., Suite 300, Phoenix, AZ 85015 (602) 640-2651, FAX 602-640-2870.

Apr. 23-24, MAPPING TOMORROW'S RESOURCES, A Symposium on the Uses of Remote Sensing Geographic Information Systems and Global Positioning Systems for Natural Resource Management, Utah State Univ., Logan, Utah. Contact: Dean's Office, Coll. of Nat. Res., Utah St. Univ., Logan, UT 84322-5200 (801) 750-2445.

May 15-17, CRATER LAKE NP 90TH ANNIVERSARY SYMPOSIUM, Southern Oregon State Coll., Ashland, OR. Contact: Dr. Frank Lang, Dept. of Biology, Southern OR/State/Coll, Ashland, OR 97520 (503) 552-6342.

May 17-20, FOURTH NORTH AMERICAN SYMPOSIUM ON SOCIETY AND RESOURCE MANAGEMENT, in Madison, WI. Contact: Donald R. Field, 1450 Linden Dr., Madison, WI 53706.

June 22-25, BIODIVERSITY TRAINING COURSE, location to be announced. See Mar. 9-12 notice above.

Nov. 16-20, PARTNERS IN STEWARDSHIP, the George Wright Society Conference on Research and Resource Management in Natural and Cultural Parks and Reserves, Jacksonville, FL. Contacts: John Donahue, NPS, 18th & C Sts NW, Washington, DC 20240 (202) 208-4274 and Harry Butowsky, NPS, PO Box 37127, DC 20013-7127 (202) 343-8155.

GIS Program Initiated at the U/AZ CPSU

By Tom Potter, Michael R. Kunzmann, and D. Phillip Guertin

Geographic Information Systems (GIS) have arrived at the National Park System in Arizona. In a joint effort at the University of Arizona at Tucson, the Cooperative Park Service Unit (CPSU/UA), Advanced Resource Technology Lab (ART) in the School of Renewable Natural Resources, and the Arizona State Museum have been working together to create GIS compatible databases for several Arizona NPS Units. So far, several themes of spatial data have been digitized for Tonto National Monument, Chiricahua National Monument, Organ Pipe National Monument, Montezuma's Castle National Monument, Wupatki National Monument, and Petrified Forest National Park. Work covering other Arizona Units is in the planning stage. Analysis and modeling of the data already captured also is in its beginning stages, but useful results have already emerged.

Initial data for each Arizona unit were digitized using a Calcomp 9500 digitizing tablet and AutoCAD (Autodesk, 1989) on a DOS-based 386 computer. The data were then loaded into IDRISI, a largely raster-, or grid-, based geographical analysis system that was originally developed as a GIS research and teaching tool for microcomputers. Since its introduction in 1987, IDRISI (Eastman, 1990) has grown to become one of the most popular raster-based GIS and image processing systems on the market. It is used in over 70 countries by a wide range of governmental and research institutions. It was chosen as the primary software for this project for numerous reasons (Table 1).

One of the objectives of the CPSU/ART program was to provide Park Units with limited staff or technical expertise with the GIS software and data that could be used directly by the existing staff. IDRISI provides a low cost, user friendly program that fulfills this objective.

Examples of Current GIS Applications

Tonto National Monument

Tonto National Monument is located on the shores of Theodore Roosevelt Lake about 60 miles east of Phoenix, AZ. The monument is known primarily for its spectacular examples of Sinagua cliff dwellings. Due to its proximity to Phoenix and Roosevelt Lake, a major concern at the unit is how increased development around the lake will affect the resources and prehistoric setting of the monument. The principal objective at Tonto is to evaluate the visual impacts of potential recreational camp sites and other development on the prehistoric viewshed.

Two basic themes, elevation data and features of interest, have been digitized for Tonto National Monument. The features of interest include entities such as the monument boundary, roads, trails, buildings and cliff dwellings. Several other themes, including a digital elevation model, slope and aspect, and a viewshed analysis were generated using appropriate IDRISI modules. Viewshed analysis consists of choosing one

Table 1. Advantages of IDRISI as a PC-based GIS

1. It is a low-cost (<$300) vehicle for teaching and scholarly research.
2. It is easy to learn and use and runs on a DOS-based PC, which would facilitate teaching GIS principles in a familiar PC environment.
3. The program is small (<2.5 Megabytes) and runs on PPC DOS-based platforms that are ubiquitous throughout the National Park Service.
4. IDRISI offers the analytical capabilities common to most raster-based GIS systems.
5. The data format is compatible with GRASS, the recommended raster-based GIS.
6. Has excellent data-interfacing capabilities with commonly used software such as Lotus 123, Oracle, dBASE, Arc/Info, and AutoCAD.
7. The software is produced and actively supported by the Graduate School at Clark University as a non-profit project.

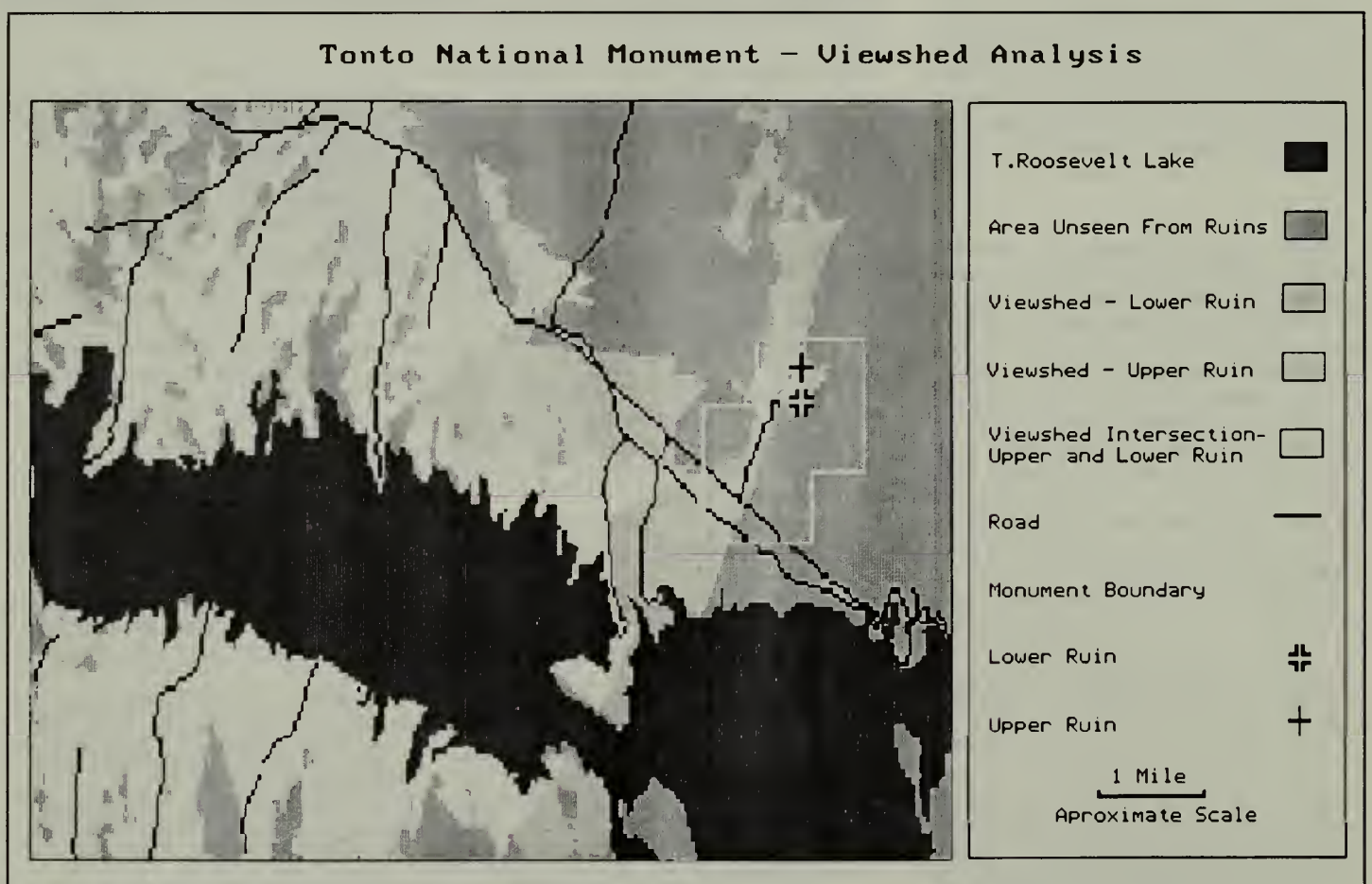

Figure 1. Viewshed analysis for Tonto National Monument and vicinity

or more viewpoints on a map and then generating another map that indicates areas that can be seen from the viewpoint(s). For the Tonto National Monument database, two viewsheds where generated, one from each of the two Sinagua cliff dwellings within the monument (Fig. 1). The monument staff now has an effective way of analyzing the impacts of proposed multi-use recreational sites on the prehistoric scene.

Chiricahua National Monument

Chiricahua National Monument is located in the Chiricahua Mountains in southeastern Arizona, about 125 miles east of Tucson. Four themes, including topography, vegetation, fire history, and physical/cultural features (Fig. 2), were digitized and loaded into IDRISI. Topography was used to create a digital elevation model along with slope and aspect. Fire data were coded by ignition cause, size, and date. With these data, and the addition of some lightning strike data, maps of fire probability and potential fire hazard can be generated. Work has also been initiated with the Laboratory of Tree Ring Research at the University of Arizona to digitize spatially-referenced tree ring data in order to map and analyze the paleo-fire history of the Chiricahua mountains.

Future GIS activities at Chiricahua will include the testing of GIS-compatible fire simulation software using data from the Chiricahua database (Ball and Guertin, 1991), and possibly the development of a model for the prediction of LD50 species mortality from fire intensity (Kunzmann et al., 1991).

Organ Pipe Cactus National Monument - Quitobaquito Springs

Organ Pipe Cactus National Monument is comprised of 300,000 acres in Southwestern Arizona and includes several distinct ecosystems. One of the unique environments in Organ Pipe National Monument is that surrounding Quitobaquito Springs, home of the endangered species, the desert pupfish (*Cyprinodon macularius* var. *eremus*). There are numerous management concerns related to the Quitobaquito Springs area, but of particular interest is how international border management will affect the springs. Of these concerns, the effect of topographic alterations on water levels in the main pond at Quitobaquito is of utmost importance.

For Quitobaquito Springs topography, vegetation, surface hydrology, and physical and cultural features were digitized and a digital elevation model and slope and aspect generated. These data are intended to help model the effects of alterations in topography on the local hydrology.

Montezuma's Castle National Monument

The data base for Montezuma's Castle is still under development. Topography and physical cultural features have been digitized and transferred to IDRISI, where a digital elevation model has been generated. As with Tonto National Monument, Montezuma's Castle is also facing increased development along its borders. Our intent is to use GIS-assisted analysis and modeling to help clarify some of the planning issues related to the monument.

Two other issues at the unit are maintaining riparian corridors along Beaver Creek and monitoring and maintaining the sensitive aquatic habitats and rich archaeological resources at Montezuma's Well, a spring-fed pool bounded by the sheer walls of a limestone sinkhole.

Wupatki National Monument

Wupatki National Monument is located in north-central Arizona north of Flagstaff. The unit preserves a series of beautiful Sinagua pueblo dwellings. The entire unit is rich in archeological resources. Dr. Ken Kvamme at the Arizona State Museum has loaded the locations of known archeological sites, topographic data, and soils data into IDRISI. With these data, he has created archeological site-probability maps that can provide information for planning purposes and help direct future archeological field surveys.

Petrified Forest National Park

Petrified Forest NP is located in northeastern Arizona, about 120 miles east of Flagstaff. The park is known primarily for the rich fossil remnants of Mesozoic forest preserved within its boundaries. But the park also preserves other unique, though lesser known, archeological, ecological, and scenic resources.

GIS work at Petrified Forest NP begam recently when a team from the Arizona State Museum started to compile and digitize data on the archeological, geo-

(Continued on page 20)

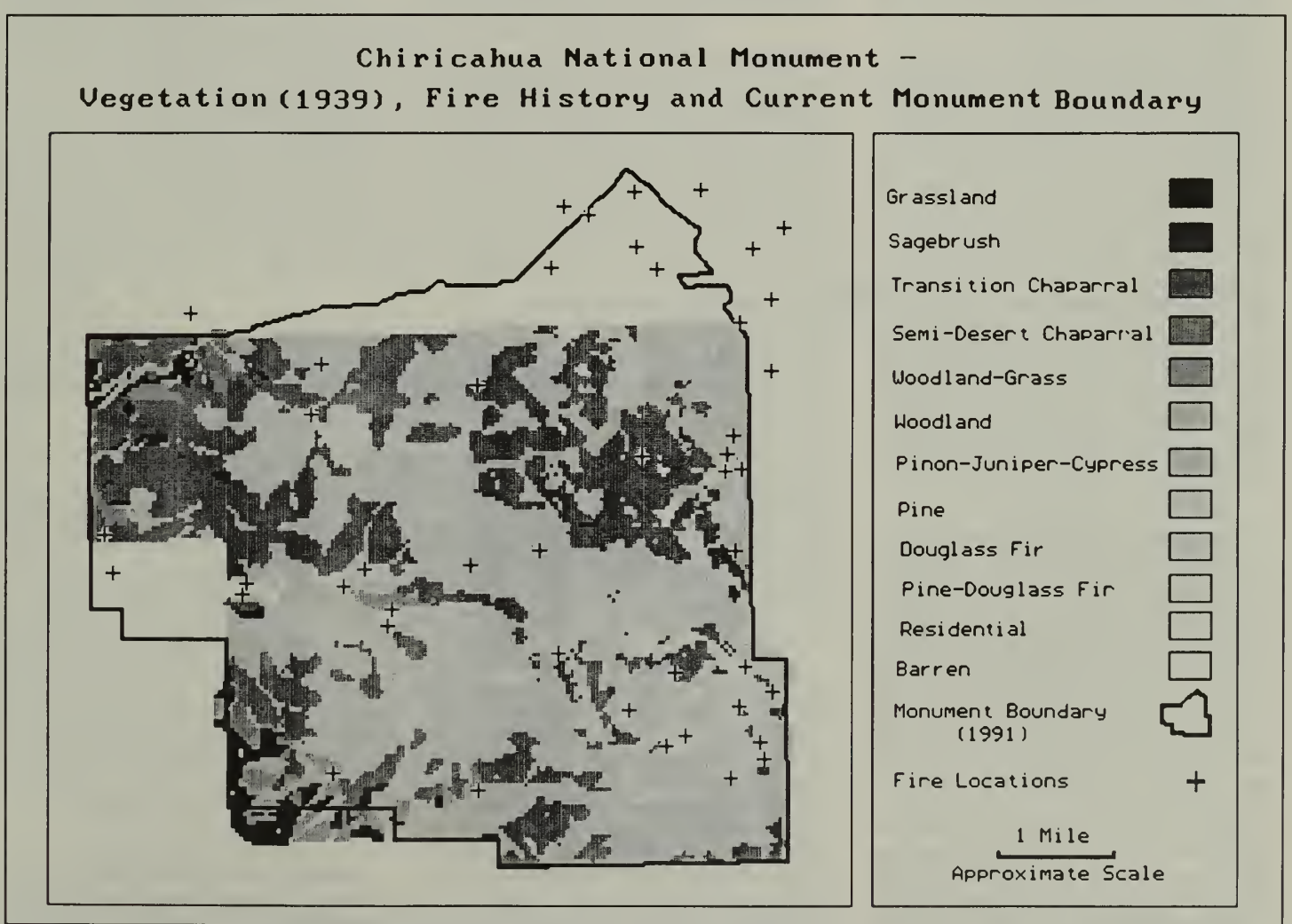

Figure 2. *Vegetation (1939), fire history and current monument boundary for Chiricahua National Monument*

Visitors Prefer Park Values to Oil and Gas Development

By George Wallace

Visitors stopping at viewing points in all three units of Theodore Roosevelt NP (TRNP) see a dramatic landscape that combines badlands, prairie, and riverbottom vistas. Such views often extend over several miles of parkland and beyond park boundaries. Park staff have felt for some time that the park's unique values may be threatened by increasing numbers of nearby oil wells, tanks, roads, powerlines, and communication towers visible from many points inside the park.

More than 1000 oil and gas wells lie within 10 miles of the park, some within a quarter mile of park and wilderness boundaries. Additional impacts associated with these sites include flare pits, electrical lines, an extensive network of roads, truck traffic noise, and accompanying dust and odors. Industrial human and wildlife fatalities have occurred near the park as a result of accumulations of hydrogen sulfide gas, which can collect near the wells. Were such human-caused landscape features affecting the visitors' experience, park visitation – hence the park's contribution to the local economy?

Despite a variety of laws and directives clearly entrusting parks with management of scenery, visual resources, viewsheds, integral vistas, and air quality related values (NPS Act 1916, Clean Air Act 1963, Wilderness Act 1964, NEPA 1969, Surface Mining Act 1977, etc.) TNRP managers frequently found themselves in hearings and negotiations attempting to stop or mitigate adjacent development but armed with little data on which to make their case.

In 1988, at the request of TRNP staff, the University of Wyoming NPS Research Center sponsored a study designed to look at the effect of external development on the economic and aesthetic values of TRNP. Researchers from Colorado State University worked with park staff to design and conduct a study that inquired into visitor perceptions, expenditures, and other related information over a 2-year period.

> "The thousands of visitors to Theodore Roosevelt NP expect and deserve more than to have their vistas marred by adjacent oil and gas development," said Park Supt. Pete Hart after the Little Missouri National Grassland Oil and Gas Final Environmental Impact Statement (FEIS) and Record of Decision (ROD) was released on Oct. 24, 1991. "The FEIS vastly understates the seen areas visitors are viewing," he said, "especially from the wilderness area.
>
> "The projection of over 500 new wells on USFS lands in the vicinity of park and designated wilderness area will severely impact the quality of the visitor experience and cause the degradation of park resources for decades to come."
>
> Hart referred to the study described in this article as having "direct management implications for dealing with external development impacts. Our major concerns are for the cultural integrity of the Elkhorn Ranch, air quality, wilderness values, and visual resources," Hart said. Formal comments on the FEIS are being prepared by the park, the Region, and WASO in a joint memorandum for signature by the NPS A/D for Planning to the Regional Forester (Northern Region.)

Study Design

On site interviews were conducted at 6 of the park's main vistas, where visitors interviewed could see large landscape areas while responding to survey items about (1) the value of a mixed grass prairie ecosystem national park like TRNP, and (2) external impacts and human-generated landscape features. This second part of the study included items best evaluated while visitors were viewing the resource and/or items less appropriate for a mail survey. Those interviewed were then given a mailback questionnaire to be filled out upon completion of their visit to the park.

The questionnaire was to gather information about (1) visitor and trip characteristics such as length of stay, group size and composition, locations visited, and activities pursued and most enjoyed; (2) visitor satisfaction; (3) expenditures associated with the visit; (4) socio-demographic information, and (5) comments.

The study was piloted in the summer of 1988, with a stratified random sample of 250 visitors, refined and continued in 1989 with a sample of 686. The number of interview days allocated each of the 6 sites was in proportion to the visitation typically received (annual visitor hours) at that site. Interviews were distributed over the summer to reflect vegetative changes in the landscape and changes in types of visitors.

Interview Procedure Features

Prior to the field interviews, photographs were taken at each of the 6 integral vistas, duplicated and enlarged to 11" x 17". On one of the paired photos for each vista, simulations either *added* or *removed* human-generated landscape features. All simulations were put to scale; added features like oil wells or powerlines were put in locations where they were slated to be built. In photos where human-caused features were removed, natural vegetative conditions were simulated in their places.

These photos were used as "cues" to help visitors make "mind's eye" judgments about a particular portion of the landscape seen during the interview as it might look under other conditions. Using the cues and the real landscape, visitors were asked to rate the attractiveness of the two landscapes and then to answer questions regarding how the simulated landscape (with external impacts either added or removed) might affect their behavior at that place (time spent viewing, picture taking, hiking, camping, and using the wilderness area in or near that landscape.)

GIS Program at U/AZ CPSU *(continued from page 19)*

logical, soils and vegetation resources in the unit. Future data acquisition efforts at Petrified Forest will likely include the collection and analysis of data from either satellite platforms or airborne video. In addition to basic research, these data will be used to predict the locations of archaeological and paleontological resources on land surrounding the unit.

Future Work

Many GIS projects are in the planning stages. Archeologist Trinkle Jones at the Western Archeological and Conservation Center (WACC) has extensive spatially-referenced archeological records in a dBASE format. Plans are in the works to develop a dBASE interface to permit directional transfer of these records into IDRISI. The Dbase/Idrisi map interface would allow park staff to easily transfer their own spatially-referenced dBASE records into IDRISI. In addition, IDRISI map files are easily transferred into GRASS, the primary GIS supported by the Service's Geographic Information Systems Division in Denver.

Efforts are under way to develop cooperative relationships with the state of Arizona and other federal agencies to collect and share spatially-referenced digital data. One example is the GAP project developed by the Fish and Wildlife Service. The GAP project will use various sources of digital data (Landsat, aerial video and other GIS-compatible data) to comprehensively map critical wildlife habitat in the state of Arizona. In a cooperative effort, the data have the potential to provide much valuable information to the parks in Arizona.

Provision of GIS training for Arizona NPS personnel also is underway. A workshop covering a wide range of GIS-related issues took place at the University of Arizona's ART lab in June of 1991. The aim of the workshop was to familiarize Park Service personnel with GIS technology and provide them with some hands-on experience. Future workshops will be held according to interest.

Conclusion

The CPSU/ART GIS program is still in the initial stages of collecting and digitizing spatial data and developing techniques of modeling and analysis. The potential for useful GIS analysis is limitless, now that the effort has been started. Park managers in Arizona have responded positively to these initial efforts and see GIS as a promising tool that can enhance their abilities to accomplish many resource management tasks. For additional information about the CPSU/ART program call Mike Kunzmann (FTS) 762-5534 or Phil Guertin (602) 621-1723.

Potter is a graduate student in the School of Renewable Natural Resources at U/AZ; Kunzmann is a research ecologist at the NPS/CPSU at U/AZ; Guertin is an assistant professor of Watershed Management at the School of Renewable Natural Resources at U/AZ.

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The Spring issue of *Park Science* will carry an article by Kunzmann, George Ball, and Petger S. Bennett, describing Dynamic Fire Modeling Using GRASS 4.0, developed at the U/AZ NPS/CPSU.

Table 1. Mean Landscape Attractiveness Ratings at Six Integral Park Vistas Cued by Photo Simulation (on a 10 point scale with 10 being most attractive), Summer 1989.

Integral Vista	Photo-Simulation				
	As Is	Man-Made Features Added	Man-Made Features Removed	(N)	% Change
Bentonite Clay	9.2	3.4	–	81	−63.0
Boicourt Ridge	5.6	–	8.5	179	+51.8
Riverbend Overlook	9.1	5.4	–	70	−40.7
Man and Grass	5.2	–	8.0	34	+53.8
Painted Canyon	6.6	–	8.8	133	+33.3
Schramm Hill	6.5	–	8.7	182	+33.8

– = no photo simulation made

Table 2a. Expected Vista-Viewing and Picture Taking Behavior, by Park Site (Summer, 1989).

	Park Site					
	Bentonitic Clay†	Boicourt Ridge*	RiverBend Overlook†	Man and Grass*	Painted Canyon*	Schramm Hill*
(N)	82	179	73	35	133	182
	Percent					
Stop coming	1.2	0.0	1.4	0.0	0.0	0.0
Spend less time	61.0	38.4	2.9	2.3	2.2	
Spend same amount of time	35.4	60.9	60.3	62.9	73.7	66.5
Spend more time	2.4	37.4	0.0	34.3	24.1	31.3

† = external development added
* = external development removed

Table 2b. Expected picknicking, hiking and camping behavior, by Park site (Summer, 1989).

	Park Site					
	Bentonitic Clay	*Boicourt Ridge*	*RiverBend Overlook*	*Man and Grass*	*Painted Canyon*	*Schramm Hill*
(N)	82	179	73	35	133	182
	Percent					
Stop coming	7.3	0.0	5.5	0.0	0.0	0.0
Spend less time	59.8	1.1	34.3	2.9	3.8	1.1
Spend same amount of time	30.5	61.8	60.3	54.3	69.2	69.2
Spend more time	2.4	37.1	0.0	42.9	27.1	29.7

Table 3. Man-made or man-caused features reported in Boicourt Ridge landscape, by order of mention (Summer, 1989).

	Order of Mention					
	First	Second	Third	Fourth	Fifth	Percent Noticing
(N)	178	175	102	43	14	
1. Oil and gas well site	97.8	0.6	0.0	0.0	0.0	98.4
2. Oil and gas well site	0.0	98.9	1.0	0.0	0.0	99.9
7. Oil and gas well site	0.6	0.0	49.0	25.6	7.1	82.3
5. Road (with scoria surface)	1.1	0.0	12.8	11.6	0.0	25.5
3. School and church	0.0	0.0	18.6	0.0	0.0	18.6
8. Access road	0.0	0.0	6.9	25.6	35.7	68.2
9. Reservoir/pond	0.0	0.0	7.8	18.6	7.1	33.5
10. Other	0.0	0.0	1.0	14.0	35.7	50.7
6. Agricultural fields	0.0	0.0	2.0	0.0	0.0	2.0
11. Other	0.0	0.0	0.0	0.0	7.1	7.1
4. Combine	0.0	0.0	0.0	0.0	0.0	0.0

Economic Analysis Features

The mailback survey enabled researchers to estimate visitor expenditures by category (transportation, lodging, food, etc.) both within 50 miles of the park and within the rest of North Dakota. These expenditures were combined with those that the operation of TRNP itself contributes to the economy (payroll, local purchases, sub-contracts, etc.) and converted to fit the categories and coefficients used by the North Dakota Input-Output Model. The IMS Regional Economic Input-Output Model developed by John McKean at Colorado State University was run using the data. Such models include the multiplier effect of expenditures for each sector of the economy and provide the estimated value of a park like TRNP to the local and state economy. Following are a few of the salient results from the study.

Economic and Non-Economic Values Revealed

The economic portion of the study revealed some figures that should enable park managers to provide information of high interest to local decision makers. In 1989, TRNP produced the equivalent of **1164** jobs in North Dakota's private sector, and an **economic contribution to the state** (changes in total sales) of **$62,740,000.** Visitors were asked during the interviews how they valued a prairie park like TRNP compared to other national parks. Although TRNP is off the beaten path and not typically a destination park, the study showed that 76.7 percent of all visitors valued the park equally as much, and 20.5 percent valued TRNP more than other parks; 94.4 percent of all visitors said that environmental laws protecting the park's resource quality should be adhered to, even if it adds to the costs of oil and gas production.

Although the information is not politically viable at the moment, the study asked – as an indicator of public sentiment – for visitor opinion about creating a 1-mile buffer zone around the park. More than 72 percent responding favored such a buffer, regardless of whether oil and gas companies were compensated; 16.5 percent favored a buffer with compensation, and 11 percent opposed any buffer. The park has a sizeable group of return users, many of whom are locals and who value the park highly. Local visitors, many of whom depend on the energy sector, were among those assigning the highest value to the park, but showed the highest opposition to the buffer zone concept (34.3%).

External Development and Visitor Experience

The study showed TRNP to be a very visually oriented park, where the most frequent and enjoyed activities are vehicle touring, stopping at scenic vistas, viewing wildlife, and day hiking. At all 6 vistas where sampling was done, the simulated removal of visual impacts (human-caused features) increased ratings of attractiveness while the simulated inclusion of visual impacts in photo cues lwered landscape attractiveness ratings (Table 1). Even subtle simulated changes in landscape features caused noticeable differences in attractiveness ratings. Increases in external development which actually occurred near interview sites between 1988 and 1989 also are distinctly reflected in the data.

In the on-site interviews, visitors were asked "if the landscape was like that shown in the simulated photo," how would it affect the amount of time they would spend (a) vista viewing or picture taking, (b) picnicking, hiking or camping, (c) or using the wilderness area nearby. Results clearly indicate that for landscapes where human-caused landscape features related to external development were added, many people reported they would spend less time or not come at all. Where development was removed, they would spend more time (again, photos were used as cues for judgments about the actual landscape) Table 2.

Although visitors still rate their experience at TRNP as good, the external development (particularly of oil and gas and its associated structures, noise, odors, and dust), is negatively affecting their experience. The context within which human-caused landscape features are seen is very important. Obviously not all

(Continued on page 22)

Restoring the Historic Landscape At Wilson's Creek

By Lisa Thomas

"The hills bore some scattering oaks and an occasional bush, but we could see clearly, because fires had kept the undergrowth eaten out and the soil was flinty and poor."

Thus was the scene described by private Eugene Ware on Aug. 10, 1881, when over 15,000 Confederate and Union solders met along the slopes above Wilson's Creek in southwestern Missouri.

Since that time, intense agricultural use and the exclusion of natural forces such as fire have changed the savanna landscape dramatically. Fescue and successional fields have replaced prairie meadows. Steep slopes that never were plowed have succeeded to forest in the absence of fire. And exotic species dominate, even in areas such as the limestone glades, where agricultural disruptions were less severe.

Since the establishment of Wilson's Creek National Battlefield (WICR) in 1960, the 1750 acres of rolling terrain has been recognized as the park's principal resource. Efforts to restore a savanna landscape began in the late 1960s with the planting of 220 acres of prairie grass. Studies completed in the 1970s and 1980s have formed a clearer picture of the historic landscape and of WICR's restoration needs. Over the last decade an additional hundred acres have been planted with native warm season grasses.

In the spring of 1991, the park completed an action plan to provide long-term guidance and priorities to landscape restoration. The plan outlines specific management objectives and prescriptions for WICR's various community types and provides a multi-year restoration timetable. The plan also identifies certain areas where more research is needed to develop restoration methods. Monitoring to assess treatment success is emphasized as a key component of the restoration process.

Restoration goals at WICR include reconstructing savanna communities in current fescue and successional fields, increasing species diversity in old prairie plantings, and reducing woody and exotic dominance on limestone glades. Over the next 3 years, restoration efforts will focus on a 330-acre area known as Bloody Hill, which contains the park's most significant historic and natural features. Eventually, 1000 acres, comprising the historic core of the park, will be restored.

The current restoration phase began in late summer, 1990, with a prescribed fire in a 35-acre fescue field. The fire promoted vigorous fescue regrowth, insuring a more complete kill when the field was sprayed with Roundup in November. In April 1991, the field was planted with prairie grasses and wildflowers that are native to southwestern Missouri.

Last summer (1991) the park's restoration crew brushhogged overgrown successional fields, sprayed exotic weeds, and cut down exotic Osage orange trees in preparation for planting. Prescribed fires were carried out in the fall.

While the restoration crew already is applying well-

Visitors Prefer *(Cont'd from p. 21)*

human-caused landscape features detract. Some are expected and add to the visitor experience. Smoke from natural sources like burning coal seams, from controlled burns, and from oil and gas wells were all evaluated differently, although most visitors were unable to distinguish among these different types of smoke.

Mitigating Impacts

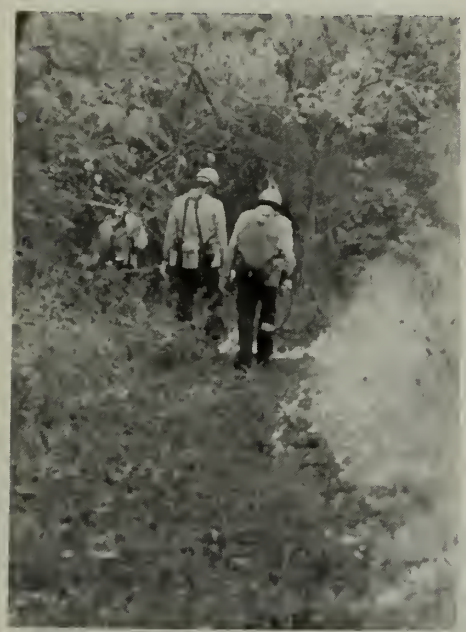
At each vista, those interviewed were asked simply to tell researchers what human-caused landscape features they saw on the landscape in question. Responses were recorded on a vista grid in the order of mention and the results compared with a master grid having all visible human caused features on it. These data, displayed for the Boicourt Ridge site in Table 3, allow managers to better understand the relative visibility of external features and to see whether managers and visitors notice the same things. Mitigation priorities (painting with earth tones, changing the color of a road surface material, moving and site planning, etc.), can become more evident with such data, and like other of the study's results, can be useful during negotiations with energy companies, county commissioners, or during the permitting and site planning process.

Study results show that TRNP is a highly valued park that makes a significant contribution to the local and state economies, a park where the principal activities pursued by visitors are being impacted by external development. Indications are that eventually this may affect the amount of time visitors spend on these activities. There is some evidence too that impacts from external development may be reducing the economic contribution the park makes to the local economy. Several factors, like displacement (some visitors may already have stopped coming), make it difficult for this study to assign an exact dollar value to the impacts of external development, but many of the results seem to stand on their own.

Results from this and similar studies will make it easier for park managers to explain the economic, aesthetic, and other values the park embodies. The data generated quantify external impacts and suggest necessary mitigation for both present and proposed external development.

Wallace is an Associate Professor in the Recreation Resources and Landscape Architecture Department at Colorado State University.

Wilson's Creek *(Cont'd)*



established restoration treatments, new methods are being developed to meet unique restoration problems. One of the goals is to increase species diversity in both old and new prairie grass plantings. Research to compare establishment success of 20 prairie wildflowers was begun in the spring of 1991. Another research project is exploring methods to reduce woody and exotic cover on the park's limestone glades. These areas require careful handling because they are home to several rare species, including the federally endangered Missouri Bladderpod (*Lesquerella filiformis* Rollins).

Park biologists currently are collecting vegetative baseline data that will be used to measure restoration success. Monitoring protocols have been developed for each restoration objective. We anticipate that such specific monitoring data are needed to judge the success of particular treatments and to identify new problems while they still are manageable.

WICR's historic restoration plan integrates research, monitoring, and management into the restoration process. Including research and monitoring components requires a greater initial commitment of resources. We expect this investment to pay off with management that is more responsive to changing restoration demands.

Our long-term goal is to restore communities that are sustainable with little management beyond periodic prescribed fire. Early management aimed at increasing native diversity and reducing exotic dominance is the key to restoring a landscape that will stand the test of time.

Thomas is a Biological Technician at WICR and is heading up the restoration project.

Editor's Note: Schoenberg, an archaeologist with the NPS Regional Office in Alaska, has worked in Alaska for 20 years. His area of research is the prehistory of arctic and boreal regions, with emphasis on adaptation and cultural ecology. In July and August of 1990, upon invitation from the USSR Academy of Sciences and with support from the Horace Albright fund, he traveled to Novosibirsk, Siberia (with a stopover in Moscow), to present a professional paper on a Beringian archaeological site in Gates of the Arctic NP. The paper was presented at an international symposium on Chronostratigraphy of the Paleoloithic of Northern Asia, organized by the Institute of History, Philosophy, and Philology of the USSR Academy of Sciences. References to the USSR were all made before recent events made that designation a dubiously descriptive title.

By Ken Schoenberg

Scholars from the USA, Canada, France, Korea, China, Japan, India, Germany, and all parts of the Soviet Union attended the Chronostratigraphy Symposium. Papers on recent discoveries in Siberia, Korea, China, the United States and Japan showed a common interest in investigating the paleoenvironment of the north and understanding cultural adptation to those environments.

Some of the most exciting recent finds, in relation to human migration to the New World, have been made in northern China, Mongolia, and the Amur region of Siberia (for instance the Ust-Ulma site that was excavated by Derev'anko). The evidence is good that the ancestral population pool of the human migrants across Beringia was centered in this area in the late Pleistocene.

Much of the discussion centered on methods of interpreting the stratigraphy of deep loess sites through the use of geological and pedological interpretation. It was agreed that dating sites through stratigraphy (chronostratigraphy) provides only relative dates. The need is to apply more multidisciplinary techniques, such as radiocarbon and thermoluminescence, in order to obtain more precise absolute dates for these sites.

Global Change Clues

The technological and financial resources to apply these and other scientific techniques to archaeological and geological research are lacking at present in Mongolia, China, and Siberia. These deep loess sites, however, appear to hold great potential for providing paleoenvironmental baseline data for global change research. Scholars in these countries are looking to Europe, Japan, and the U.S. for expertise, facilities, and equipment to pursue more in-depth research on these sites.

The paper I presented, "The Archaeology of Kurupa Lake: A Northern Beringian Site," describes a site just north of the Brooks Range in Gates of the Arctic NP. This site has been occupied intermittently over the last 8000 years, and shows similarities to sites in Siberia and northern China that warrent further investigation.

One key point made in this session was that Beringian research, both archaeological and biological, would benefit greatly from investigation of sites geographically close to one another, such as on either side of the Bering Strait and Chukchi Sea. Too often, especially in northern archaeology, sites that are several thousand kilometers apart are compared, and the intervening gap is ignored. There is need for a "chain of sites" that are geographically close, to provide comparative data links across the existing gaps.

Beringian Park Proposal

The Beringian Heritage Park proposal between the NPS and the Soviet Union is one attempt to facilitate such research. The idea of the park (unknown to most of the researchers at the symposium until I presented it) was enthusiastically received. Another mechanism to sponsor Beringian research was presented by Hans Muller-Beck of Germany, who chairs a committee on human entry to the New World for the International Quaternary Union (INQUA). This committee is organizing an interdisciplinary and international research effort on both sides of the Bering Strait.

The conference revealed a basic problem in the lack of a common scientific terminology among scholars in different countries. Lack of such a descriptive and analytical framework makes communication and comparison of data and interpretation difficult. NPS is attempting, as part of the Beringian Heritage project, to address this problem through the development of a Russian-English archaeological dictionary. If this project is successful, then as the need arises, dictionaries for other disciplines could be undertaken.

I traveled with a group of colleagues from Novosibirsk to the Lake Baikal region of Siberia, visiting archaeological sites and exploring the national park areas around the lake. We met with local residents and managers and discussed resource management problems there (consumptive use of resources and anthropogenic change) as well as the impact of the park on their lives.

Field Camps Visited

After traveling to Irkutsk, our first field camp was at the southern end of the Bratsk Sea, formed by the damming of the Angara River, which is the only outlet of Lake Baikal. This area has been the scene of intensive archaeological work in the last 20 years because the formation and industrialization of the Bratsk reservoir has led to major environmental degradation of the area. About 100 meters of shoreline has been eroding every decade, exposing numerous archaeological sites.

Our hosts informed us that the environmental movement in the USSR gained its first real strength in response to environmental problems in this area and threats to the unique ecosystems of Lake Baikal. One response was the founding in 1971 of a National Park around parts of Lake Baikal.

The second field camp we visited was at the headwaters of the Lena River, near the town of Verkolensk, founded in 1641 by Russians and Cossacks as part of their conquest of Siberia. It also was the place to which the Czar exiled Leon Trotsky prior to the 1917 Revolution. The archaeological sites in this area date back at least 20,000 years, and are characterized by deep loess deposits even though the area has been heavily forested at various times.

Our last field camp was at Ulan-Hada Bay on Lake Baikal. The Geophysical Institute of Irkutsk maintains a permanent research camp (of tent frames) there. Because this part of Lake Baikal is shallow and the water warms up enough for bathing and boating, there is a long history of human occupation here. There also is a productive fishery at the boundary of the shallow, warm bay and the cold, deep waters of the main lake. The area is the main recreation area around the lake for visitors from all over the Soviet Union. Local authorities would like to see greatly increased international tourism here. Management of this complex park, which lacks an institutional park service with traditions and expertise, is evolving on a day-to-day basis.

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New Publications

Eight new publications have been announced by and are available from Donna O'Leary, NPS Natural Resources Publication Coordinator (P.O. Box 25287, Denver, CO 80225-0287; FTS 327-2156, (303) 969-2156).

1. *NPS Annual Science Report: 1990 Inventory of Research Activities in the National Parks*. Anne Frondorf, ed. Data sorted by region and park: NRSR-91/04; Data sorted by field of study: NRSR-91/05.

2. *Proceedings of the Symposium on Exotic Pest Plants*. Ted D. Center, Robert F. Doren, Ronald H. Hofstetter, Ronald L. Myers, and Louis D. Whiteaker, eds. NRTR-91/06.

3. *Annual Report of the National Park Marine Debris Monitoring Program: 1990 Marine Debris Surveys*. David A. Manski, William P. Gregg, C. Andrew Cole, and Daniel V. Richards. NRTR-91/07

4. *1990 Highlights of Natural Resources Management*. Lissa Fox, ed. NRR-91/03.

5. *Designing and Implementing Comprehensive Long-term Inventory and Monitoring Programs for National Park System Lands*. David G. Silsbee and David L. Peterson. NRR-91/04.

6. *White-tailed Deer in Eastern Ecosystems: Implications for Management and Research in National Parks*. William F. Porter. NRR-91/05

7. *Developing a Natural Resource Inventory and Monitoring Program for Visitor Impacts on Recreation Sites: A Procedural Manual*. Jeffrey L. Marion. NRR-91/06

8. *Air Quality Management Plan: A Prototype, Colonial National Historical Park*. Sandra Manter, Charles Rafkind, Erik Hauge, and John Karish. AQD/NRR-91/01.

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Park Science, A Resource... XX

PARK SCIENCE

A Resource Management Bulletin

Volume 12-Number 2 National Park Service U.S. Department of the Interior Spring 1992

An Integrated Approach to Marine and Terrestrial Research in Virgin Islands National Park and Biosphere Reserve

By Caroline S. Rogers

Virgin Islands NP comprises a little over half (2,816 ha) of the island of St. John (U.S. Virgin Islands) in the Caribbean Sea. Established in 1956, the park was expanded in 1962 to encompass 2,287 ha of the surrounding waters. St. John's topography is rugged, with deep valleys and hills that rise abruptly from the coastline. Over 80 percent of the slopes exceed 30 percent. The highest point on the island is 387 m above sea level. St. John has no permanent streams or rivers, but erosion channels ("guts") form narrow valleys through which intermittent streams discharge into the sea. The island supports dry evergreen and moist forests and is surrounded by coral reefs, seagrass beds, and clear waters.

Virgin Islands NP was designated an international biosphere reserve (BR) in 1976 and is one of the few BRs that has both marine and terrestrial resources. In 1987, the Virgin Islands Biosphere Reserve Center, which houses the park's Division of Research and Resource Management, was completed. UNESCO's Action Plan for BRs echoes NPS policy in calling for compilation of baseline data on natural resources and long-term monitoring of protected ecosystems as reference points for comparison with less protected environments. More detailed information on natural variations in ecosystem structure and function will permit more effective resource management and a better understanding of the effects of human activities on the environment.

In this issue of ***Park Science*** we present a series of articles on the research program in Virgin Islands NP which focuses on long-term assessment of marine and terrestrial ecosystems, particularly coral reefs and forests of St. John. Many of the ongoing studies have evolved from work carred out from 1984-1989 by NPS and other members of the Virgin Islands Resource Management Cooperative (VIRMC). The approach has been to encourage comprehensive and complementary research on the island's natural resources, especially within critical watersheds (e.g., Lameshur and Cinnamon Bays).

Most of these projects represent several years of monitoring. For example, Dr. Peter Weaver, with the

Continued on page 27

Trunk Bay *in Virgin Islands NP and Biosphere Reserve. (Photo by Sharon K. Sneddon).*

PARK SCIENCE

NATIONAL PARK SERVICE

SPRING 1992

A report to park managers of recent and on-going research in parks with emphasis on its implications for planning and management

ARTICLES

DEPARTMENTS

MISCELLANEOUS

editorial

Evidence of the strong chord struck by the Vail conference celebrating the National Park Service's 75th anniversary is contained on page 14 of this issue. The monumental job of assessing "who we are and what for us is true" (to quote a hymn) that started in October 1991 in Vail, Colorado, is continuing throughout the Service. Rick Smith's observations succinctly state the feelings of others who contacted the editor, while Loren Fraser's letter acknowledges the bases for these feelings and describes the steps being undertaken at the directorate level to involve the entire Service in addressing them. It is just such lively and open expressions that keep hope very much alive, and which justify pride in our present as well as our past.

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In the Next Issue

The Summer issue of ***Park Science*** will feature Paleontological Research and Resource Management in the National Park System. Nearly 70 NPS areas with significant fossil resources have been identified ... some are classic fossil collecting localities and continue to support active paleontologic research.

The history of life on earth is well represented, ranging from Precambrian stromatolites of Glacier NP to an Ice age mammoth in Arches NP. Dinosaur, Fossil Butte, John Day, and Petrified Forest employ fulltime paleontologists to coordinate fossil research.

The management of paleontological resources on federal lands is becoming a critical issue, and coverage of this subject area is overdue. The cooperation between professional paleontologists and park staff will be apparent in the Summer issue.

In addition, the Francis Singer article on Yellowstone northern range ungulates will (we hope) be ready in time for the Summer issue. Also scheduled are 2 visitor studies that we were unable to fit into this issue: a Visitor Use Reporting study at Acadia NP (by Kenneth Hornback and Robert Manning), and a study by Manning and Margaret Smith on evolving significance to visitors of Roosevelt Campobello International Park.

Impacts of Natural and Human Disturbance On Forests of St. John, U.S. Virgin Islands

By Anne E. Reilly

For years, researchers have been exploring changes in successional patterns and processes in plant community development following disturbance events (Pickett and White 1985). Understanding the disturbance effects on vegetation is important for land managers involved with protection and acquisition of parks and reserves. Effects of both human and natural influences often promote different responses in vegetation.

Human Disturbance

The history of the island of St. John, U.S.V.I., is similar to that of many other islands in the Caribbean. Originally the island was completely forested, but as numerous groups of Ameri-Indians and Europeans settled here, the island landscape began to change. Initially, the impact probably was minor, since many of the early arrivals existed by hunting and gathering. As other groups arrived, some land was developed for subsistence agriculture. Eventually, with the arrival of Europeans, a large scale plantation economy emerged. It is during this period that the greatest changes in the island's forests most likely took place.

Approximately 90 percent of the forests were removed during the 1700s and 1800s, when the sugarcane industry was at its peak (Tyson 1987). A combination of factors eventually led to the demise of this exploitive economy; emancipation of the slaves, declining soil fertility, increasing erosion, and the low price of sugar. Following this period of intense environmental destruction, the land was abandoned. The few individuals who remained practiced subsistence agriculture; thus, the forests began to recover.

The Virgin Islands were purchased by the United States from Denmark in 1917, and in 1956 approximately 50 percent of the land was designated as a national park. Protection of more than half the island provided a unique research opportunity (Reilly et al 1990).

In 1985-86, the St. John Forest Dynamics Project was initiated with NPS support. Over the years other institutions also have been involved – the Yale School of Forestry, the New York Botanical Garden, The University of the Virgin Islands, and U/GA's Institute of Ecology. The intent of the research program was to monitor forest regeneration in relation to past land use history as part of the Virgin Island Resource Management Cooperative's (VIRMC) islandwide study of three critical watershed systems. This is the sixth year of the long-term monitoring program.

Natural Disturbance

Humans have significantly modified this landscape. Some researchers believe the current vegetation is much drier than what originally was present, due to the long lasting effects of the plantation economy (Woodbury and Weaver 1987). However, natural forces also have played a role in the disturbance regime, hurricanes being the most severe form. It is estimated that once every 70 years a severe hurricane will pass over an island (Neumann et al 1978). The most recent such, affecting St. John, was Hugo in the fall of 1989 (Reilly 1991).

Despite the damage they pack, hurricanes appear to increase species diversity (Weaver 1989). They provide a myriad of habitats, which can support many different species due to variety of light and moisture environments. Empirical evidence from long-term studies of hurricane influenced forests (Crow 1980, Weaver 1986) indicates specific patterns of forest recovery following hurricanes in terms of species richness, tree density, and basal area.

***Looking at the forest canopy** through the eye of a hemispherical lens. Image analysis software used in conjunction with the photograph will enable quantification of incoming light.*

Forest Dynamics Project

The goal of current research is to investigate the role of disturbance, both natural and human induced (i.e. past land use history) in three forest plots on the island. Disturbance plays a key role in determining the species composition and physiognomy at each site. The degree of disturbance in a particular forest area may promote different responses in the vegetation.

Three permanent forest plots have been established within the boundaries of Virgin Islands NP to investigate the impact of these disturbances. The plots are representative of the surrounding forests, can be separated along a moisture gradient, and are in three different watersheds. Using the local names and the vegetation classifications of Woodbury and Weaver (1987) the areas can be described as: Bordeaux, upland moist forest, 1.0 ha in size, located on the Reef Bay watershed; L'Esperance, gallery moist forest, 1.0 ha, located in Fish Bay watershed; and Hawksnest, dry evergreen woodland, 0.5 ha, in the Hawksnest Bay watershed. Within these plots, all stems 5 cm or greater have been identified to the species level, measured to the nearest mm, and mapped to the nearest 0.5 meter. In addition, 250, 1x1 sub-plots have been established to examine seedling regeneration in the forest plots.

To date, well over 6,000 stems have been examined for rates of growth and mortality, levels of recruitment, hurricane damage assessment, and other factors. In addition, several hundred seedling plots have been studied to assess changes in species composition and percent cover over time, and – fortuitously for this study – changes due to hurricane damage.

The forest at Bordeaux is approximately 100 years old, based on the plantation's time of abandonment shown in tax records (G.Tyson and S.Edwards, pers. com.). This 1-ha site contains 63 species, represented in 34 families (Table 1). This plot is dominated by native species, of which some of the most common are *Guapira fragrans* (black mampoo), *Pimenta racemosa* (bay rum tree), *Inga fagifolia* (amarat), *Ardisia obovata* (breakbill), and *Byrsonima coriacea* (hogberry).

The L'Experance plot supports trees that are approximately 80 years old (G.Tyson and S.Edwards, pers. com.) and is home to 56 species in 29 families (Table 1). This 1-ha site also is dominated by native species. Most commonly encountered are *Ardisia obovata, Guapira fragrans, Andira inermis* (pig turd), *Ocotea coriacea* (pepper cillament), and *Chrysophyllum pauciflorum* (palmat).

Hurricane Impacts

The diameter and height of the stems in the forest, the species composition, and the topography of the landscape as well as the direction of the winds, all affect the response of the forest to a hurricane. Each stem was ranked into a damage class category that

Continued on page 4

Forest Service Research in Virgin Islands National Park

By Peter Weaver

In cooperation with the University of Puerto Rico, Rio Piedras, the U.S. Forest Service began research in the Virgin Islands NP in 1982 with a survey of the park's vegetation (Woodbury and Weaver 1987). All natural and naturalized species of herbs, shrubs, and trees found on St. John and Hassel Islands were identified, and a herbarium was created in the park. A list of species with their relative abundances by vegetation type also was prepared. The flora of St. John contained at least 116 families and 792 species; 66 families and 297 species were enumerated for Hassel Island; 18 species were designated as rare or endangered, and 6 of these appeared to be new to science. The medicinal uses of many species also were described.

The main vegetation types on both islands were classified and mapped. More than 60 percent of St. John has dry evergreen formations (Table 1). The moist forest formations occupy about 16 percent of the island. In contrast, mangrove, salt flat, and lagoon areas are limited in extent. The remainder of the park is covered with secondary vegetation, pasture, and urban areas. Hassel Island, only about 54.2 ha, is in Charlotte Amalie harbor, and contains mangrove, moist basin forest, dry evergreen thicket, thorn and cactus, coastal hedge/rock pavement, and secondary scrub comprised of *Acacia*, *Croton*, and *Leucaena*.

Impacts on Virgin Islands Forests *(continued from page 3)*

Table 1. Summary of forest characteristics at three permanent sites.

Study Site	*Bordeaux*	*L'Esperance*	*Hawksnest*
Area	*1 hectare*	*1 hectare*	*0.5 hectare*
Watershed	*Reef Bay*	*Fish Bay*	*Hawksnest Bay*
Approximate Age	*100 years*	*80 years*	*45 years*
Life Zone	*Upland Moist Forest*	*Gallery Moist Forest*	*Dry Evergreen Woodland*
Species and Family Richness	*63 species* *34 families*	*56 species* *29 families*	*51 species* *27 families*
Dominant Species	*Guapira fragrans* *Pimenta racemosa* *Inga fagifolia* *Ardisia obovata* *Byrsonima coriacea*	*Ardisia obovata* *Guapira fragrans* *Andira inermis* *Ocotea coriacea* *Chrysophyllum pauciflorum*	*Melicoccus bijugatus* *Guapira fragrans* *Bursera simaruba* *Ocotea coriacea* *Eugenia monticola*

indicated whether there was loss of a primary or secondary branch or whether the stem was snapped off or tipped over. Results from Hugo suggest that taller and larger diameter trees usually were more severely damaged than shorter, smaller diameter trees; that forests on slopes facing the winds were more damaged than leeward forests, and that low elevations received more damage than higher elevations within each site (Reilly 1991).

Current work is focusing on the recovery of forests to hurricane damage. One method being employed to document these changes is the use of hemispherical photography. A fish-eye lens is used to photograph an upward looking image (i.e. the forest canopy) in a 180-degree field of view. This image is processed with an image analysis software package, to estimate light that is reaching the forest floor and thereby facilitating growth. Six weeks following Hurricane Hugo the canopy above all seedling plots was photographed. In fall 1991, another set was taken in the same locations. Results of this work should indicate the resilience of these systems to natural disturbance.

Changes in percent cover and species composition triggered by the recent hurricane also are being investigated. Data were collected in the spring before Hugo, and then again in the spring of 1991. Preliminary analysis indicates changes in both species composition and percent cover (Reilly unpub. data).

Future work will provide further insight into the patterns and processes of these tropical forest ecosystems. Of specific interest are canopy-seedling interactions, species distributions as influenced by topographic position, mortality and recruitment rates of native and exotic tree species, and changes in forest composition through time. Understanding the responses of vegetation to the impacts of natural and human disturbance – the sensitivity or the resistance of these systems – should greatly aid management of these limited natural resources.

Reilly is a doctoral student at UIGA's Institute of Ecology. She has been investigating tropical plant community ecology on St. John for the last 6 years.

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Long-term Ecological Studies

Cinnamon Bay encompasses about 1.32 km^2 in the north-central park of St. John (Fig. 1) and receives about 1300 mm/yr of rainfall. The watershed ranges in elevation from sea level to about 330m in the southeast, only slightly more than 1 km from the shore. The rough topography is characterized by steep slopes and numerous ravines with streambeds devoid of water except after heavy rains. A pronounced soil moisture gradient exists at all elevations from well-drained ridges and upper slopes to the moister lower slopes and ravines.

The response of ecosystems to biotic influences and random events is best assessed through long-term sampling on representative permanent plots. In 1983, the U.S.F.S. initiated the island's first long-term terrestrial research in the Cinnamon Bay watershed. Sixteen permanent 50 x 10 m plots were stratified in groups of three by topographic positions (ridge, slope, and ravine), at elevations of about 60, 120, 180, 210, and 240 m, with the last plot located near the summit. Objectives of the study were to determine species composition, structural characteristics, species-site relationships, and growth rates in the forest (Weaver and Chinea-Rivera 1987). Heights, diameters at breast height, and crown classes were recorded for all trees over 4 cm. Sixty-nine tree species were identified from the 2,698 stems sampled on all plots.

The 10 most common species accounted for 65 percent of the stems and nearly half of the basal area. *Maytenus elliptica* had the greatest density, averaging 428 stems/ha. In contrast, *Torrubia fragrans* averaged 4.9 m^2/ha and occurred on 15 plots, giving it the highest basal area and frequency of occurrence, respectively, of any species in the watershed.

Stem density in the Cinnamon Bay watershed is high, with the number of trees averaging 3,370/ha for all of the plots. The highest tree density is found on the summit and the lowest in the ravines. The mean height and diameter for all tallied trees is about 8 m and 9 cm, respectively. Basal area averages about 30 m^2/ha. Mean heights and diameters for all stems vary little by topography; however, when only the largest trees in each plot are considered, tree heights and diameters are greatest in the ravines and smallest on the ridges.

A statistical approach (Reciprocal Averaging ordination) was used to detect elevational trends and topographic preferences for 35 species that occurred at least three times in the data set. The major groupings were: ridge species from low to high elevation; cosmopolitan species; ravine species from low to high elevation; slope species; and, transition species from valley to ridges at low elevations. Site information for tree species, especially those considered to be rare or endangered, is useful for locating them in the wild and for vegetative restoration projects.

Tree Growth and Forest Dynamics

All of the Cinnamon Bay plots were re-measured in 1988 (Weaver 1990). At this time, 206 new trees were recorded (representing ingrowth, or stems growing into the minimum diameter class) whereas 161 stems died. This flux in tree numbers yielded an average increase of 12 stems/ha/yr during the 5 year period of measurement.

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Smithsonian Institution's Permanent Monitoring Plot: Research Opportunities in a Rare, Semi-Evergreen Dry Woodland

By Francisco Dallmeier and Gary Ray

In March, 1990, the Smithsonian Institution's Man and the Biosphere Biological Diversity Program (SI/MAB), with NPS cooperation, established a forest monitoring plot 1-ha in size, within the boundaries of the Virgin Islands NP. The permanent plot encompasses a stand of dry forest, an ecosystem which is underrepresented in the Smithsonian Institution's international network of forest monitoring plots.

Dr. Francisco Dallmeier, Director of the Smithsonian's SI/MAB Biological Diversity Program, and Gary Ray, a graduate student from U/WI-Madison, initiated the project. The interest in St. John's dry forest is based on its status as a minimally disturbed ecosystem protected by a national park and located within a biosphere reserve, which can serve as a reference study site for comparable ecosystems elsewhere in the Caribbean.

Among the objectives of the SI/MAB program are the establishment of sampling protocols so that widely differing sites may be compared temporally and spatially, and to enhance the professional training capabilities of the host-country. The biosphere reserve on St. John exhibits two elements, location and management, which provide an excellent case study for the Caribbean. Information gathered from the study plots is intended as a standard for evaluating future ecological changes against a matrix of human-altered ecosystems.

Since the Caribbean's dry forests have largely been eliminated, and the remaining stands degraded, forest relicts under study bear significant conservation value, both regionally and globally. Information on the composition and structure of St. John's dry forests can be used in many Caribbean developing countries where degraded forests need to be managed and restored.

Dr. Dallmeier is with the Smithsonian Institution; Ray is a graduate research assistant at U/WI-Madison.

Forest Service Research in the Virgin Islands NP *(Continued from page 4)*

Mean annual diameter growth for the 2,538 trees that survived was 0.07 cm/yr. Differences were apparent by crown class with dominant trees averaging 0.10 cm/yr, codominant and intermediate trees 0.08 cm/yr, and suppressed trees 0.06 cm/yr. Basal area increment for all plots averaged 0.26 m^2/ha/yr. Only one species, *Rauvolfia nitida*, disappeared from the plots, and no new species were recorded.

Hurricane Assessment and Productivity

On Sept. 18, 1989, Hurricane Hugo passed near St. John, doing considerable damage to the island's forests. In July 1990, all trees in the Cinnamon Bay plots were classified according to damage: uprooted, snapped, or little disturbed. In April 1991, all tags that were damaged or removed by the hurricane were replaced.

In May 1991, seven trees were harvested from approved locations, and leaves, branches, and trunks were oven-dried and weighed separately to yield biomass estimates. Based on data from these trees and 13 trees sampled in the wet limestone forests of north-central Puerto Rico, common equations were developed to predict leaf and woody biomass from stem dimensions (total tree height and diameter). These equations are currently being used in conjunction with the 1983 and 1988 plot measurements to determine biomass accumulation on the 16 plots, and to asssess biomass losses attributable to Hurricane Hugo.

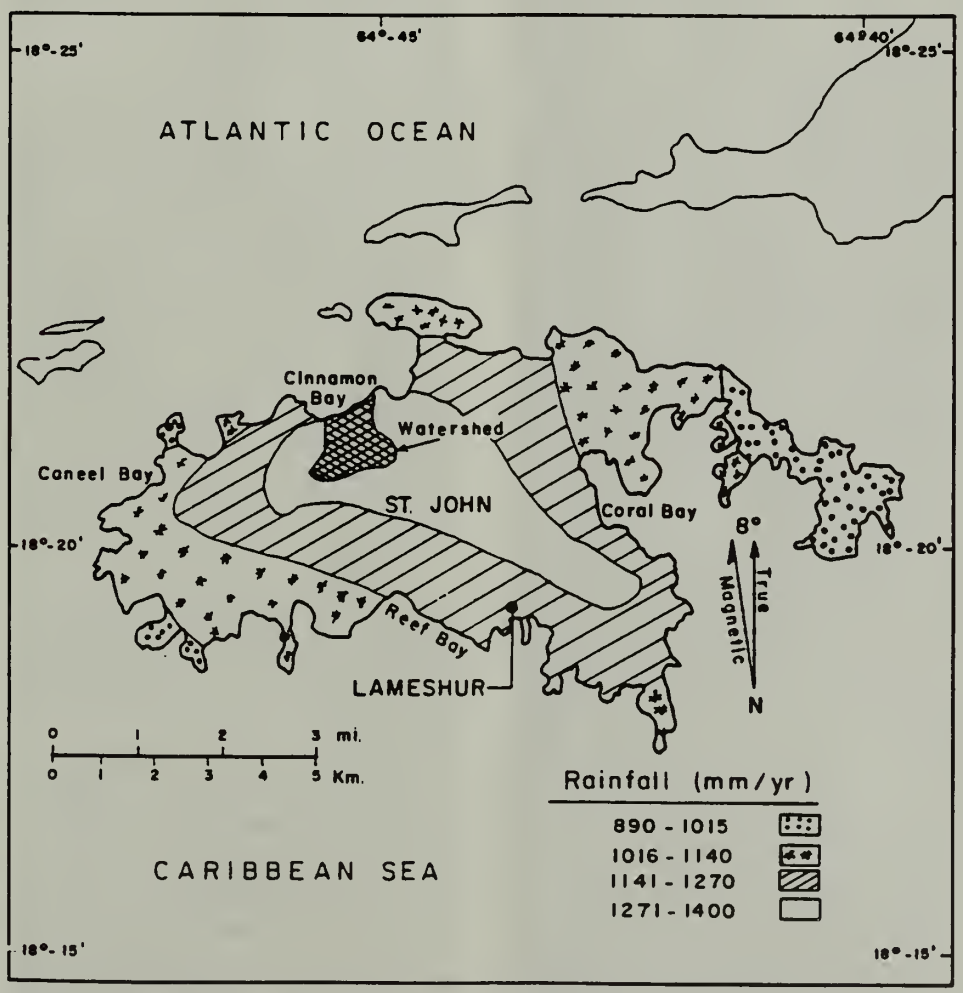

Figure 1. *St. John Island and the Cinnamon Bay watershed. Rainfall isoyets are also indicated.*

Table 1. *Vegetation Types on St. John*

• Dry evergreen formations	
– Woodland	33.4%
– Thicket	21.5%
– Thorn and cactus	6.3%
– Coastal hedge/rock pavement	2.1%
• Moist forest formations	
– Upland forest	8.9%
– Gallery forest	3.9%
– Basin forest	3.6%
• Mangrove, salt flat and lagoon areas	2.3%
• Secondary vegetation	13.4%
• Pasture	2.0%
• Urban areas	2.6%
TOTAL	100.0%

Studies of litterfall, loose litter, and herbivory were initiated in February 1992. Data from these studies will be analyzed along with biomass accumulation rates to estimate the productivity of the Cinnamon Bay forest. Monitoring of all permanent plots will occur again in 1993. The 10-year record should provide reliable estimates of incipient changes in forest composition caused by Hurricane Hugo.

Dr. Weaver is with the Institute of Tropical Forestry in Puerto Rico.

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Restoring the Degraded Dry Forests of Virgin Islands NP

By Becky J. Brown, Gary J. Ray, and Tamra C. Mendelson

Virgin Islands NP, located on the 48 km2 island of St. John in the U.S. Virgin Islands and covering 56 percent of the island, consists of land that has been severely degraded by previous cultivation and livestock grazing. None of the original forest survives; however, a mosaic of secondary forest in various stages of recovery presently occupies almost all of the park. The native tropical dry forest plant community once covered most of the Caribbean islands, including most of St. John. Parts of St. John's natural areas are now inhabited by weedy and exotic species that deprive the land of its previous natural diversity.

Tropical dry forests were once a widespread and important vegetation type on Caribbean islands. While there are few undisturbed dry forests remaining to serve as models for our project, we do know that the typical tropical dry forest community consists of about 40-50 tree species per hectare, and is characterized by a relatively large number of rare and endemic species. Tropical dry forests occur in regions of low rainfall. Rainfall on St. John ranges from approximately 800 to 1500 mm/year and is highly sporadic, without well-defined wet or dry seasons (Fig. 1). Hurricanes in the region have infrequent, but severe impacts on the forest community.

The native plants of the tropical dry forest have developed strategies to deal with a stressful environment. They produce fruit primarily when environmental conditions are favorable, and growth is generally slow. Very little is known about the regenerative process in these forests, and prior to our study almost nothing was known about how to restore dry forest on degraded sites.

The loss of pristine forest on St. John prompted us to propose an ecological restoration of dry forest on one of the most degraded sites in the park. Initiated in 1988, the project is funded by the U.S. Man and the Biosphere Program (MAB), with additional support from the NPS. The major objectives of this project are to better understand the dynamics of tropical dry forest and to develop techniques for restoring the biodiversity of degraded dry forest habitat.

Mary Point, a peninsula on the north side of St. John, is the site of our restoration efforts. Historical records and aerial photographs indicate that the south-facing slope of Mary Point was heavily grazed for nearly 200 years, before the park was established. Forest recovery since then has been extremely slow. In 1988, about 30 years after the cattle and goats were removed, the area remains a tangle of thorny vines and weedy pioneer trees (Fig. 2). Hurricane Hugo devastated the vegetation of Mary Point in September 1989 and further retarded the recovery process.

A seedling inventory conducted in 1990 documented that although seedling densities were as high as 53 seedlings per square meter, only 6 tree species were represented. More than 98% were *Leucaena leucocephala*, a weedy, exotic tree species. These data show a species-poor seedling community at Mary Point, and suggest that active management may be required to restore the biological diversity of this forest community.

Testing Restoration Techniques

From the more than 100 tree species in the mature dry forest on the island, we selected ten target species for our initial restoration work (Table 1). These include both deciduous and evergreen species from the canopy and the understory strata.

Our goal at Mary Point is to enrich the diversity of the regenerating forest and, if possible, to hasten the recovery process. To reach this goal, we are first trying to determine which regenerative stage is limiting forest recovery. For example, rapid recovery of the forest on severely degraded sites may be inhibited by a shortage of seeds of dry forest species. Such a paucity of seeds would be expected after a long period of livestock grazing. If a lack of seeds is the primary factor limiting forest recovery, then importing seeds to the site may expedite the regenerative process. We are testing this hypothesis by broadcasting seeds of the 10 target species into experimental plots and monitoring germination and seedling survival. In 1990 we introduced 10,800 seeds of 6 species, and by June of 1992, we will have introduced a total of 14,000 additional seeds of 10 species. So far, the germination rates in the field have been quite low. In the shadehouse under more favorable conditions, germination rates on the same species are high (Table 1). The low germination in the field probably reflects unpredictable rainfall patterns, combined with the fact that seeds of many species lose viability quickly after dispersal. Our results thus far suggest that simply importing seeds to Mary Point may not be an effective means for accelerating forest regeneration.

We are also transplanting shadehouse-grown plants (Fig. 3) into the field, in order to test the idea that forest recovery can be accelerated by bypassing the germination and seedling establishment stage. We are field testing plants grown both from seed and from vegetatively propagated stem cuttings. We are growing these plants in shaded and unshaded plots to compare the feasibility of two restoration techniques: (1) planting cleared areas, versus (2) underplanting weedy and exotic species with natives. We are also testing the usefulness of Terrasorb, a soil moisture enhancing agent, in promoting seedling survival and growth. In

Table 1. *Regeneration characteristics of ten target species in tropical dry forest restoration project at Virgin Islands National Park.*

Species	Dispersal Agent	Germination Rate (%)	Vegetative Propagation (% Rooted)
Bursera simaruba	Bird	59	10
Capparis cynophallophora	Bird	83	0
Coccoloba microstachya	Bird	75	67
Guaiacum officinale	Bird	92	0
Guapira fragrans	Bird	91	17
Guettarda parviflora	Bird (?)	47*	8.7
Pisonia subcordata	Mammal (?)	87	0
Plumeria alba	Wind	96	22
Sabinea florida	Autochory	99	12
Tabebuia heterophylla	Wind	96	36

**Data expressed as percentage of fruits germinated. Multiple embryos per fruit increases germination success to 81 seedlings per 100 fruit planted.*

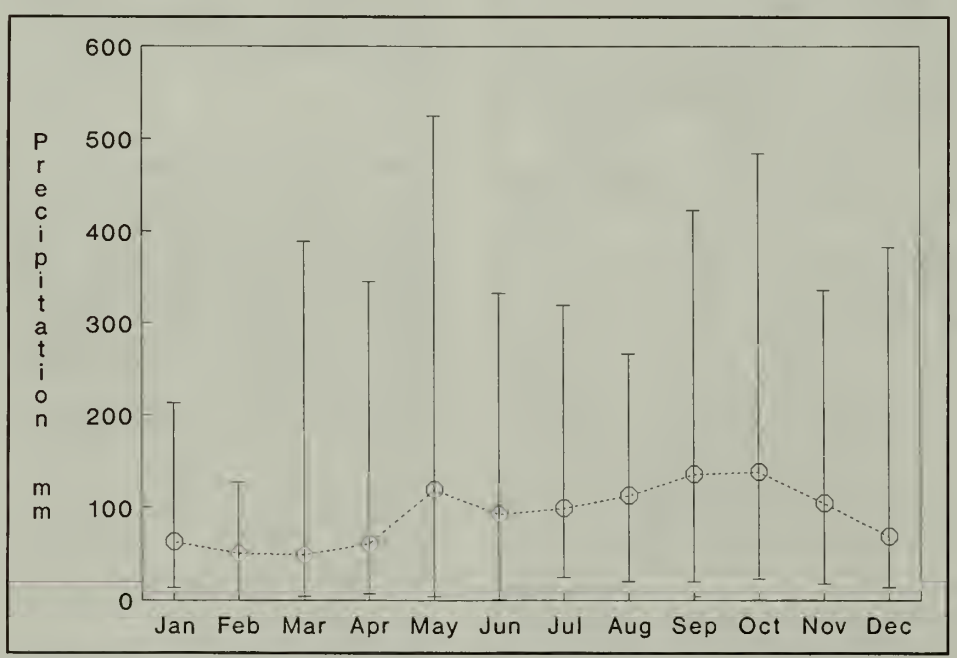

Figure 1. *Precipitation at Cruz Bay, St. John, Virgin Islands, 1871-1989. Circles show average monthly rainfall; bars indicate ranges.*

1990 we introduced 1152 seedlings of six species into field plots. We introduced 1000 additional seedlings and stem cuttings of 9 species in 1991. After 9 months we will estimate growth and biomass increment of surviving plants. This experiment will give us detailed information about growth requirements of each of the 10 target species.

Our shadehouse tests show that some, but not all, of our target species can be propagated vegetatively from stem cuttings (Table 1). The relative success of transplanted seedlings and cuttings in the field is yet to be determined. If results show high survival rates for cuttings, then vegetative propagation may prove to be an effective method for restoring species for which seed collection and germination are difficult.

Dry Forest Dynamics

Tied to our restoration experiments are ongoing field observations and measurements in secondary dry forests on St. John. Here the focus is on documenting the dynamics of the dry forest community. We are tracking the flowering and fruiting phenology of a total of 300 trees of 15 species. It appears that flowering and fruiting success are closely tied to weather conditions and vary greatly from year to year. Species such as *Pisonia subcordata* produce fruit during spring or early summer when rainfall is likely. Flowering in other species, such as *Sabinea florida*, may be triggered anytime of the year by rainfall after a long drought.

In 1988 we established 11 permanently marked 10 m X 50 m plots at 5 sites on the island. In these plots all mature trees more than 4 cm in diameter were tagged, and subplots were established for monitoring the growth of saplings and tree seedlings. These long-term plots will be monitored to assess naturally-occurring changes in species composition and stand structure.

A few hundred donkeys roam freely throughout the park. Although plans for management of the donkey population are being developed by the NPS staff, currently the donkeys present a serious threat to native vegetation in the park, particularly in the drier habitats. Donkeys show preferences in their choice of forage, and it appears that some native plants are much more vulnerable to donkeys than are others. Our experience indicates that *Bursera simaruba* and *Pisonia subcordata*, two important dry forest tree species, are particularly susceptible to donkey damage. Through their selective feeding, over time, donkeys can seriously alter the composition of the dry forest. Donkeys may in fact be an important factor inhibiting the recovery of the native vegetation at Mary Point. A 10 m X 50 m exclosure established as a part of our restoration project will help to document the long term effects of donkeys on the dry forest vegetation.

Management Implications

Our research is currently in an experimental phase. Results of our field investigations, scheduled for completion in 1992, will provide the ecological information needed to carry out a large-scale forest restoration at Mary Point. Management recommendations based on our research must be adapted to local biophysical and socioeconomic conditions. However, because of similar climate, soils, topography and land use histories on the drier islands of the Caribbean, the basic ecological information from our research should transfer readily for use in designing reforestation projects on other degraded dry sites.

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Figure 3. *Shadehouse-grown plants are transplanted into the field, bypassing the germination and seedling establishment stage.*

Figure 2. *Gary Ray, assessing seedling performance in a weedy, abandoned pasture at Mary Point, the site of the ecological restoration project.*

Effects of Hurricane Hugo on a Coral Reef in St. John

By Caroline Rogers

In 1988, the National Park Service initiated a long-term coral reef assessment program for Virgin Islands NP. A primary objective was to establish permanent long-term sites on coral reefs around the island. In January 1989, we established five 20 m transects on the coral reef that fringes Yawzi Point, the point which separates Little and Great Lameshur Bays. This reef slopes to a depth of about 14 m where it ends in a well-defined sand channel which separates the base of the reef from a seagrass bed. We selected the Lameshur Bays for long-term study sites because they are in the core of the biosphere reserve and relatively undisturbed by human activities.

The permanent transects lie along the 12 m depth contour. Twenty-three hard coral species occur in the transects, with an additional 10 species observed elsewhere on the reef. We surveyed the transects in January, June/July, and November 1989 (following Hurricane Hugo); March, August, and November/December 1990; and in June 1991 (see Rogers et al. in press, for details).

Changes in Coral Reef Structure After Hugo

During Hurricane Hugo, powerful storm seas fragmented and overturned coral colonies. Waves hurled fragments or entire colonies of coral into other colonies leaving visible impact scars. Coral rubble collected in large piles in sand channels and other depressions in the reef. Damage was patchy, with some portions of the reef exhibiting more destruction than others. This patchiness, noted in other studies of storm damage, reflects differences in reef depth and structure, as well as the differing susceptibility of reef organisms to physical damage (Woodley et al. 1981).

At some sites around St. John, the storm surge transported loads of sediment and buried coral and gorgonian colonies. Off Yawzi Point, however, we did not observe smothering by sediments. Water quality was poor due to turbidity associated with rainfall during and after the storm and suspension of reef sediments. However, the turbid conditions probably did not last long enough to have serious deleterious effects on the reef organisms.

The following are some of our key findings at the Yawzi Point site since Hurricane Hugo:

• Living coral cover: In the November 1989 survey, the living coral cover showed a significant decrease, from about 20 percent to about 12 percent, a drop of about 40 percent (Fig. 1). Coral cover has not increased significantly in subsequent surveys, although there has been some healing of coral scars.

• Diversity: The dominant coral species, star coral (*Montastrea annularis*), has shown a statistically significant decline but remains the most abundant species. Neither the diversity (H') not the evenness (J') of the survey transects increased as a result of the storm.

• Substrate: The amount of substrate available for colonization (pavement and dead coral) increased significantly following the storm.

• Topographical relief: Although one would expect a decrease in topographical complexity after a major storm, especially on reefs dominated by branching species such as *Acropora palmata*, we did not observe any decrease at the Yawzi Point site. Topographical relief could actually increase after a storm if coral fragments and colonies were transported into the transects or if colonies in the transects split into several fragments.

• Algal cover: Macroscopic algal cover increased dramatically immediately after the storm and then fell to pre-storm levels by March 1990. Algal cover had risen again by the November 1990 survey and remained high in June 1991.

Changes in Algal Cover

The dramatic shifts in algal cover observed after Hurricane Hugo are probably the result of a combination of factors. Monitoring of fish populations indicates a decline in herbivorous fishes around Yawzi Point after the storm, reducing grazing pressure on reef algae (Beets and Friedlander 1990). By March 1990, when macroscopic algal cover had declined in the transects, parrotfishes and surgeonfishes had significantly increased (Beets and Friedlander 1990). Macroscopic algal cover may also have declined because algae were dislodged by strong currents or wave action.

We do not know if grazing pressure in the Lameshur Bays has been reduced because of overfishing, a decrease in fishes at the site as a result of Hugo, or a decrease in the number of the herbivorous black sea urchins *Diadema antillarum* during the Caribbean-wide epidemic (D. Levitan pers. comm.). These urchins are presently not abundant at the study site.

Coral Reef Recovery

Recovery of hard coral populations takes place through 1) settlement, survival, and growth of sexually produced coral recruits; 2) healing and regeneration of damaged colonies; and 3) growth of coral fragments (e.g., Connell 1973, 1976, 1978, Endean 1976, Loya 1976, Highsmith et al. 1980, Pearson 1981, Highsmith 1982). The rate of recovery will be affected by factors such asthe morphological and life-history characteristics of the dominant species, the nature of the damage sustained by that species, changes in algal cover, and the occurrence of additional storms.

In 1980, Hurricane Allen devastated the Discovery Bay reef in Jamaica causing the greatest mortality among the most abundant branching species, *Acropora palmata* and *Acropora cervicornis* (e.g., Porter et al. 1981, Woodley et al. 1981, Knowlton et al. 1990). Because *Montastrea annularis*, a slow-growing species with low rates of recruitment (Bak and Engel 1979) is the dominant coral at our study site off Yawzi Point, recovery will probably be comparatively slow. As a result of Hurricane Hugo, live cover by *M. annularis*, decreased by about 35 percent at Yawzi Point, and 34 percent at a nearby reef (Edmunds and Witman, in press). The new substrate created by the storm may provide additional settling surfaces for other hard coral species such as *Agaricia agaricites* and *Porites porites* which have relatively high rates of recruitment (Bak and Engel 1979). However, colonization, survival, and growth of coral recruits will only occur in the absence of intense competition from algae.

Human activities before and after storms can influence not only the speed but also the nature of recovery. For example, extreme overfishing in Jamaica has reduced the populations of herbivorous fishes, resulting in algal smothering of small corals and algal encroachment on the periphery of larger colonies (Woodley 1989). Algal biomass has also increased because of mortality of the sea urchin *Diadema antillarum* (Hughes et al. 1987). Hughes et al. (1987) observed dramatic declines in coral cover (up to 60%) because of competition with algae.

Recovery will be delayed by natural processes such as additional storms, intense predation, algal overgrowth, and coral diseases. Populations of the once-dominant reef-building coral *Acropora cervicornis* have failed to recover at the Discovery Bay reef after destruction by Hurricane Allen in 1980 in spite of this species's fast growth rate, because of a combination of factors, including predation and algal growth (Knowlton et al. 1990, Hughes et al. 1987). Hurricane Gilbert smashed the Discovery Bay coral reef 8 years after Hurricane Allen.

Even in the absence of major additional storms,

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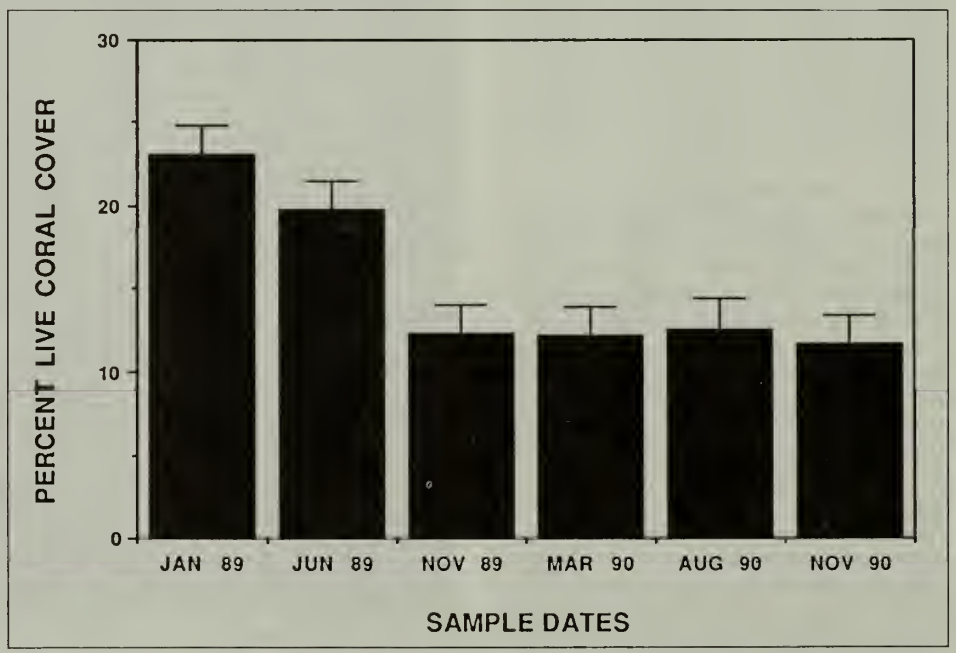

Figure 1.

Mapping and Describing the Soils of St. John

The National Park Service and Soil Conservation Service (SCS) are cooperating in a study to map and characterize the soils in several watersheds on the island of St. John. Both agencies are interested in monitoring soils to detect changes that result from local climate variations or natural processes of plant community succession and in augmenting the limited database on moisture and temperature of tropical soils.

In addition, careless and unregulated clearing and development of lands both within Virgin Islands NP ("inholdings") and adjacent to the park's boundary raise concerns over erosion and runoff of sediment into nearshore waters. Detailed data on the islands's soils should lead to greater understanding of the processes that influence the stabilization of terrestrial uplands.

The SCS will use the data collected to better understand the effects of different plant communities, and soil temperature and soil moisture regimes, on soil-forming processes in the semi-arid Caribbean setting. Ultimately, SCS hopes to improve its ability to predict a given soil's behavior under various, specific types of management.

Currently, the SCS is updating the U.S. Virgin Islands Soil Survey. Soils in the Cinnamon and Lameshur watersheds were mapped in July 1991. SCS will study soils occupying dominant landscape positions within each watershed and soils associated with the permanent vegetation plots in the park. Vertical soil profiles will be excavated, sampled, and analyzed with assistance from the National Soil Survey Laboratory.

Monitoring of changes in vegetation in permanent plots and changes in the physical and chemical nature of the associated soils will help elucidate critical soil/plant community interactions and increase knowledge of Caribbean forest structure and dynamics. Automated data collection instruments have been installed in the Lameshur watershed near the University of Wisconsin plots to record hourly changes in soil temperature and moisture at depths of 4, 8, and 20 inches.

This cooperative project on soils began in August 1991 and will continue for at least three years. It is hoped that additional funding can be found to support collection of especially valuable long-term data on the soils of St. John.

John Davis, *Soil Conservation Service*
Caroline Rogers, *National Park Service*

***Collecting data** on soil temperature and moisture.*

Hurricane Effects *(Continued from page 8)*

recovery will be delayed and additional damage may occur if loose coral fragments, detached boulders, and rubble are tossed around in strong currents. In cases where the actual framework of the reef structure has been altered, re-establishment of the pre-disturbance topography may never occur.

Future Plans

We plan to continue monitoring of the Yawzi Point study site, and an additional site which we established at Newfound Bay, off the east shore of St. John. Here, one 100 m long transect was installed at a depth of about 10 m. This transect was surveyed in August 1990 and March 1991. In 1991, Dr. Bill Gladfelter conducted quantitative surveys of gorgonians and sponges along the Yawzi Point and Newfound Bay transects to augment the data we have obtained on hard corals.

Current programs establishing long-term monitoring of coral reefs should start to enable scientists to differentiate long-term fluctuations on the reefs from responses to anthropogenic and natural disturbances (Brown and Howard 1985). As Hatcher et al. (1989) point out, "the non-equilibrial nature of coral reef communities makes it difficult to determine "standard" reef conditions against which to evaluate impacts". Major progress in understanding recovery processes will require more information not only on hard coral populations but also on gorgonians, anemones, sponges, fishes and the other organisms which contribute to the spectacular diversity of coral reef systems.

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Rogers is NPS Research Biologist at Virgin Islands NP.

Flora of St. John

The preparation of a comprehensive flora for the island of St. John is progressing well after many consecutive years of field work. The island has been thoroughly explored, in a search for all species of vascular plants. Many plant specimens have been collected and deposited at the herbarium of the Virgin Islands National Park for reference and further study.

Pioneering work was done by Dr. Roy O. Woodbury (retired Professor from the University of Puerto Rico) who collected the first specimens and published a checklist for the plants on St. John. He discovered four species which proved to be new. His work constitutes the starting point for this floristic project.

Additional field work has been done in an effort to collect every species of vascular plant on the island. As a result, a few more species have been added to the checklist, and the information on phenology and distribution of the species have been expanded. The status of the rare and endangered species of plants is better understood as new populations have been found.

The "Flora of St. John" will contain complete descriptions of the vascular plants, and information about distributions and local uses. Two hundred line drawings will illustrate about 400 of the 800 species occurring in St. John. The descriptions are primarily the work of Dr. Pedro Acevedo with some contributions by a few colleagues from the Smithsonian Institution. This work will be published in two volumes, each one describing about 400 species. The manuscript for the first volume should be ready in October 1992.

Dr. Pedro Acevedo
Smithsonian Institution

Assessment of Coral Reef Fishes in Virgin Islands National Park

By Jim Beets

Disturbance has been demonstrate to be extremely important to community structure (Sousa 1984). Coral reef fishes are particularly vulnerable to disturbance. When different components of the coral reef community are disturbed either by natural or anthropogenic disturbances, species in the fish assemblage are differentially affected based on their association, e.g., plankton-planktivores, algae-herbivores, invertebrates-predators. Catastrophic storms tend to affect most trophic levels of fishes by disrupting their food supplies or, more generally, by affecting their shelter. Lack of shelter, which enables fishes to avoid predation, may limit fish abundance.

Observed effects of Hurricane Hugo and recovery

The sustained monitoring program, which began in 1988 in Virgin Islands NP, has provided a rare opportunity to observe the effects of a hurricane on coral reef fishes and their subsequent recovery. We selected three different reef types around St. John and sampled them monthly with a random point visual technique (Bohnsack and Bannerot 1986). We censused fishes in the two predominant zones present on the fringing reef system within the park, the upper forereef and lower forereeef.

Census data demonstrated that the abundance of all fish species declined at the monitoring sites as a result of Hurricane Hugo and remained depressed for the next three months (Fig. 1). Some herbivorous fishes (primarily surgeonfishes) significantly increased following the storm, probably in response to the enormous increase in algal growth (Mann-Whitney U Test, $P<0.001$).

Most species showed substantial recovery during the first year following Hurricane Hugo (e.g., parrotfishes, Fig. 1). Although total fish abundance has returned to pre-storm levels, the proportion of the surgeonfishes was greater one year after the storm than before it (Fig. 1). There herbivorous fishes have maintained much greater abundance compared to pre-storm levels.

A few species, such as planktivorous fishes (e.g., *Chromis* spp.) were greatly affected by the storm and have shown very slow recovery. The abundance of most species is dominated by juveniles.

The storm had a varied effect on different fish species within the study area. Most larger species were probably displaced from the shallow water monitoring sites to deeper reefs as previously observed by Walsh (1983) for a reef in Hawaii. Predation of small individuals due to habitat loss and displacement was also certainly an important factor. Declines in abundance, habitat shifts and behavioral changes in many species were observed during the first month following the storm, as described in previous investigations (Woodley et al. 1981, Kaufman 1983, Walsh 1983). Displaced species appeared to redistribute themselves during the several weeks following the storm. The redistribution of fishes and colonization by juveniles contributed to recovery in abundance of most species during the 6 months after Hugo.

Storm-generated change in coral assemblages in exposed sites, especially the decrease in topographic complexity, decreased the amount of shelter available for many fish species, especially cryptic species, such as basslets, cardinalfishes, blennies and gobies, and for recently-recruited juveniles. The loss of topographic complexity and decline in living coral cover may favor the abundance of larger, schooling herbivorous fishes and turf-tending damselfishes living in the coral rubble. The effect of the hurricane on reef fish assemblages was most pronounced in areas where branching corals (particularly, elkhorn and staghorn) previously comprised the structure of the reef and shelter for fishes was dramatically reduced. The slow recovery of some planktivorous species may be due to reduced recruitment or slow recovery of the associated plankton community, which has been shown to change following major storms (Woodley et al. 1981).

What's in the Future?

Although we have been able to observe the local effect of a major storm, we need a more thorough understanding of coral reef fish ecology and a determination of the best methods for monitoring reef fishes. We will continue to sample different habitats and to evaluate various methods to provide a more complete view of the fishes and fisheries within the park and surrounding shelf area. Many questions may not be answered until we have accumulated several years of data. We can expect natural fluctuations in species abundances, but we may see shifts in species dominance based on successful recruitment, changes in ecological and oceanographic conditions, and human influence.

One of our greatest concerns is the effect of commercial, artisanal, and sport fishing on fish assemblages within the park. We look forward to cooperating with the National Park Service on a major fisheries project to begin this year.

Dr. Beets is Chief of Fisheries, U.S.V.I. Division of Fish and Wildlife.

(Literature cited on page 11)

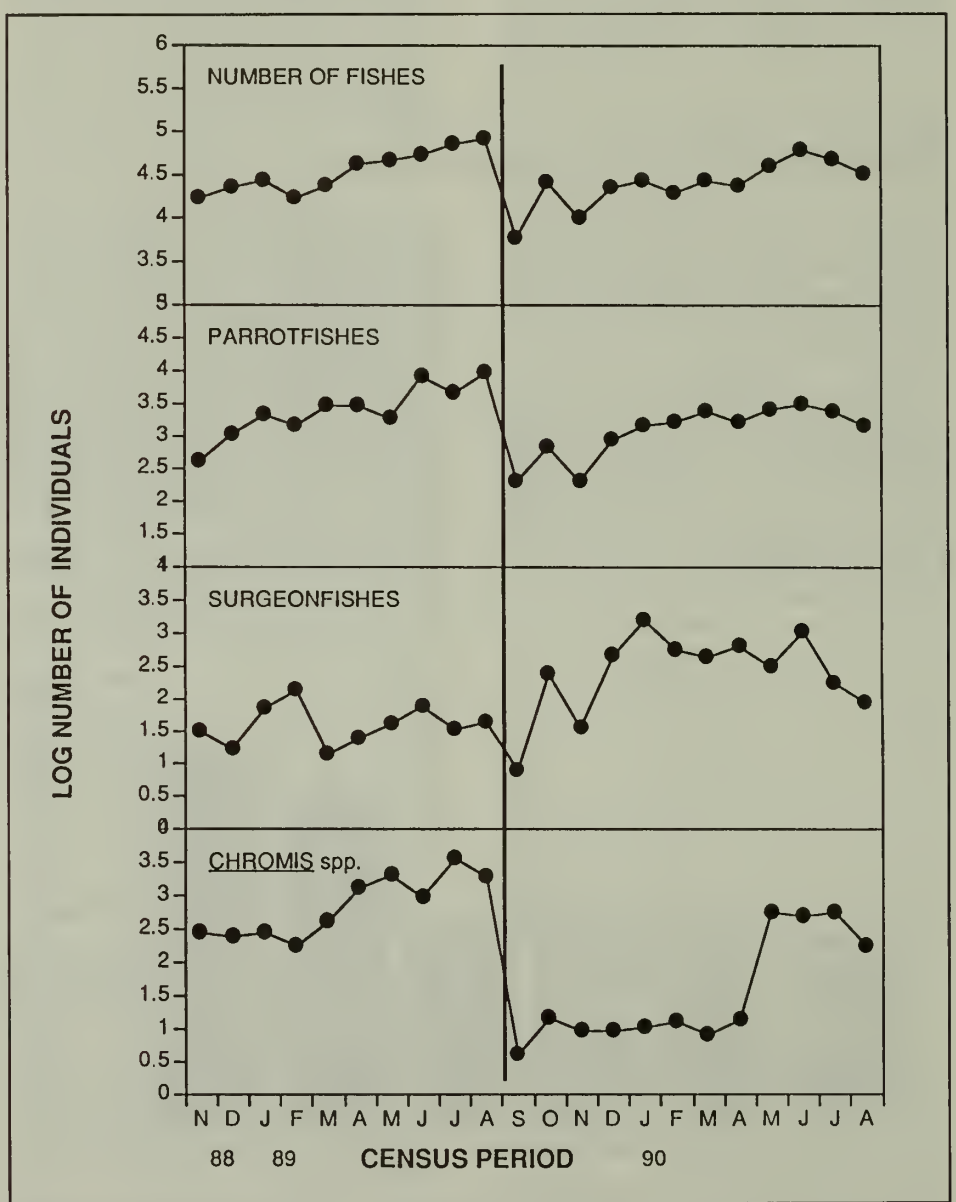

Figure 1. *Relative changes in total abundance offishes and of dominant fish taxa before and after Hurricane Hugo. Data are presented log-transformed (LN X + 1). Parrotfishes and surgeonfishes are herbivorous species;* Chromis *spp. are planktivorous damselfishes. Vertical line represents date of Hurricane.*

Monitoring Water Quality in Virgin Islands National Park

By Giglia Beretta and Craig Tobias

While over half of the island and 2,287 ha of the surrounding waters are protected within the boundaries of Virgin Islands NP, (VINP). St. John is subject to the same types of developmental pressures that are currently affecting numerous other Caribbean islands. The waters that surround the island and the numerous white sand beaches are perhaps the biggest attraction to the park for visitors from all over the world. More fundamentally, the nearshore waters provide important habitats for complex communities. The characteristically clear waters (low nutrient levels), provide ideal conditions for growth of corals, seagrasses, and a host of other marine organisms.

Sparked by tourism-based economies, development in the Caribbean is occurring at an alarming rate and may prove to be the single greatest pressure facing tropical marine ecosystems. Over the past 25 years, visitation to Virgin Islands National Park has increased drastically, with many visitors arriving on cruise ships and small boats. In 1966, an average of fewer than 10 boats per day used park waters. By 1989, this figure had jumped to averages of 70-80 boats per day in the park (Rogers et al. 1990). As with many islands in the Caribbean, there is a need for good baseline data on water quality. Such data are essential to researchers and park managers as tools for understanding and pinpointing changes affecting marine ecosystems.

In 1988, VINP began its water quality monitoring program encompassing sites both inside and outside the park. Twenty-nine sites, (16 within VINP and 13 outside of VINP), are sampled on a monthly basis. The parameters measured include salinity, dissolved oxygen (D.O.), conductivity, pH, temperature, and turbidity. Salinity, D.O., conductivity, pH and temperature are measured in situ, at the 'surface' (at a depth of 1m), using a Hydrolab Surveyor II Datasonde. Beginning in 1989, subsurface temperatures have also been measured at Lameshur Bay (on the island's south shore), using Ryan Tempmentors. The Tempmentors are secured at the site of permanent transects used to monitor coral cover at sections of the reef, and record temperature every 2 hrs. Turbidity, (water clarity), is evaluated in three ways: 1. by using a Secchi disk, to estimate the depth at which the disk is no longer visible, 2. by analyzing 150ml samples taken from 15-20cm depth, with a Turner TD 40 Nephelometer, and 3. by lowering a Martek Model XMS Transmissometer over the side of the boat to measure percent light transmission in the water column.

Some Key Findings

- **Salinity, pH, and Conductivity**

Apparently, there are no inter-annual trends with salinity, pH, and conductivity. There was little fluctuation between sites and years for these parameters. Averages for all sites from January 1988 until March 1991 were 35.52ppt, 7.58 and 53.87mmhos/cm, respectively. Marine systems, primarily due to greater mixing, generally experience little variation of these parameters. This is especially true for St. John which possesses no substantial estuaries or fresh water input, and has a relatively well flushed coastline.

- **Dissolved Oxygen**

The average D.O. concentration for all sites for this sampling regime was 6.63mg/l. Reef Bay, Rendezvous Bay, and Chocolate Hole had markedly higher average D.O. concentrations than the mean at 8.02, 7.15, and 7.79mg/l respectively. Dense seagrass beds, (dominated by *Thalassia testudinum*), characterize these sites, elevating local dissolved oxygen concentrations as a result of photosynthesis. In contrast, the lowest average D.O. concentration of all sites was 5.94mg/l at Cruz Bay. This is not surprising, as this very shallow site has a barren, muddy bottom, with little flushing, but constant resuspension of sediments.

- **Temperature**

Temperature fluctuated little over the sampling period. An overall low of 24.47°C was recorded in March 1989 at the ferry dock in Cruz Bay, while the highest surface temperature was recorded in August 1991 at Coral Bay (30.82°C). A comparison of temperature data taken at Lameshur Bay for monthly surface temperatures (measured with a Hydrolab Surveyor II), and from the subsurface tempmentor shows slight increases at both depths. Mean surface and subsurface temperatures increased from 27.02°C to 27.90°C and from 27.10°C to 27.49°C respectively, from 1989 to 1990. Temperature data, especially from the Lameshur Bay site, is an integral part of a database established to monitor temperature changes in association with coral bleaching episodes (as increases in water temperature have been suspected of triggering bleaching).

- **Turbidity**

Over the past four years, turbidity has increased for sites outside of park boundaries as well as for sites within the park. However, for each year, turbidity values have been consistently higher for sites outside of the parks boundaries (Fig.1). Trends in transmissometry (initiated in 1989), support our findings with the nephelometer turbidity data.

Measurements of percent light transmission and nephelometry readings indicate that Cruz Bay, Great Cruz Bay, Fish Bay and Coral Bay Harbor, all outside of the park, have the highest turbidity measurements of the 29 sites sampled. All are extremely well sheltered bays with naturally poor water circulation. However, it is doubtful that the relatively high turbidity encountered in these bays is due solely to geographic location, and/or physical structure of the embayments. Because of their location outside VINP, these sites experience upland development of the watersheds draining into the bays, and virtual unregulated commercial use of their waters. The significantly poorer water clarity of sites outside of VINP boundaries indicates that restrictions on development and commercial use of embayments within the park is contributing to higher water quality of the bays protected within the park.

Continued on page 12

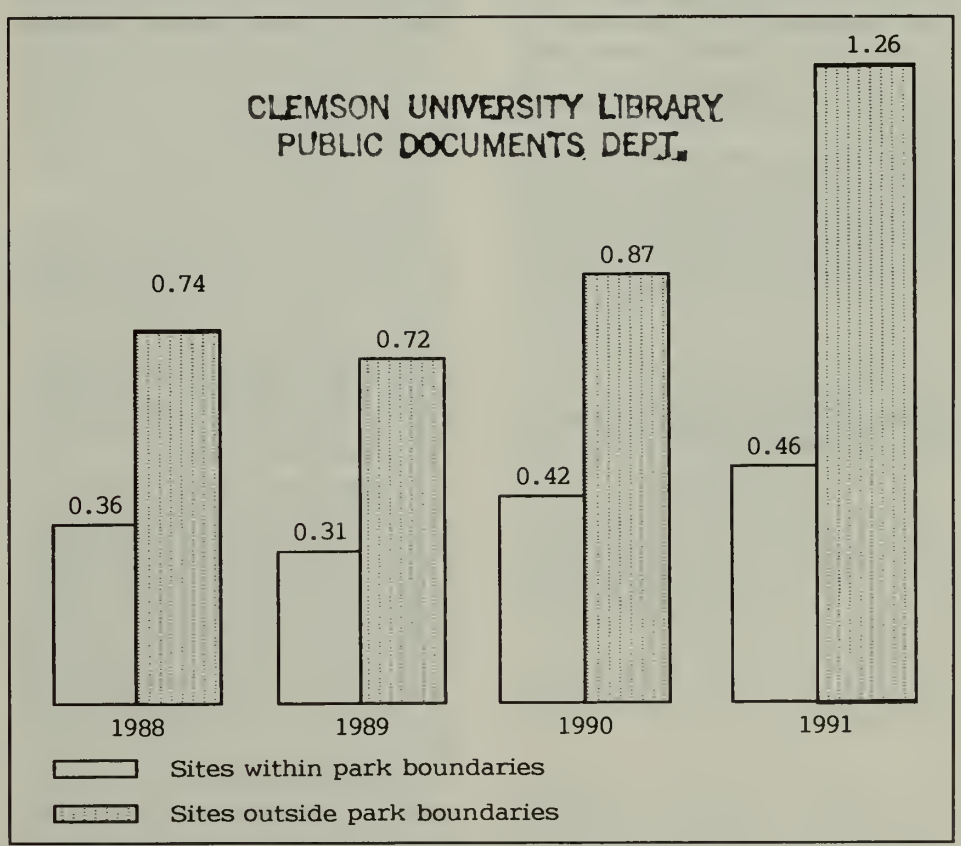

Figure 1. *Mean Turbidity (NTU) for Sites Inside and Outside of Park Boundaries*

Reef Fishes *(Cont. from p. 10)*

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Population Studies of Migratory Birds in Virgin Islands National Park

By Robert A. Askins and David N. Ewert

The majority of the individual songbirds nesting in the deciduous forests of eastern North America migrate to the West Indies, Central America and South America during the winter. They typically spend more than six months in tropical winter habitats. Until recently relatively little was known about their habitat requirements during the winter, but increasing concern about declining populations of many migratory songbirds combined with widespread alarm about the rapid destruction of tropical forests has led to a flurry of research on this subject (Terborgh, 1989; Askins et al. 1990). In 1987 we initiated a study of the ecology and behavior of migrants in the Virgin Islands, particularly in Virgin Islands NP on St. John. This study has not only yielded information about the winter ecology of migratory birds, but also about the distribution of resident species and (unexpectedly) the impact of a major hurricane on bird populations.

Habitat Requirements of Migratory Songbirds in Winter

Unlike other islands in the Virgin Islands group, St. John has large continuous tracts of moist tropical forest and dry woodland. Establishment of Virgin Islands NP in 1956 insured protection of much of the forest that was growing back on land that had been covered with sugar cane or pasture in the 19th century (Tyson, 1987). After completing an intensive survey of birds on St. John in February and March of 1957, Robertson (1962) concluded that some species of winter-resident migrants that were considered rare on nearby islands were widely distributed in the moist forests of St. John. Moreover, records from Christmas Bird Counts indicate that St. John has a higher diversity of winter-resident warblers than the other major islands in the U.S. Virgin Islands, St. Croix and St. Thomas (Pashley and Martin, 1988). These results suggested that Virgin Islands NP might include important habitat for migratory songbirds.

To assess the importance of different habitats for wintering migrants, we surveyed birds in the dominant habitats on St. John and St. Thomas. Land-use patterns on the two islands are dramatically different; St. John is 86 percent forested while 62 percent of St. Thomas is covered with commercial and residential areas, and only 38 percent is forested (Askins et al., in press). The remaining forest and woodland on St. Thomas is in the form of relatively small, disjunct patches. Our primary goal was to compare similar natural areas on the two islands to determine if forest fragmentation on St. Thomas had resulted in relatively low densities of migratory birds.

We surveyed birds at 218 points scattered across the two islands (Askins et al., in press). We counted all birds detected within 25 m of the point during a 10-minute observation period. Survey points were located in moist forest, dry woodland, and artificial habitats (e.g., hotel grounds and residential areas). Vegetation surveys were completed on a plot centered at each survey point.

We recorded an impressive diversity of winter residents during these surveys: 13 species of warblers and one species of vireo (Askins et al., in press). Like Robertson (1962), we found that the density of winter residents is more than three times higher in moist forests than in dry woodlands, and that some species were largely restricted to moist forests. Artificial habitats had relatively low densities of winter migrants and many species were never recorded in this habitat. Consequently, moist forest is a critical habitat for winter residents.

On St. Thomas, most moist forests are in steep-sided ravines (guts) surrounded by residential areas or on mountain tops that are being subdivided for housing. In contrast, the moist forests of St. John are embedded in extensive tracts of dry woodland. The remaining moist forests on St. Thomas have a vegetation structure similar to those on St. John, but the density of winter residents is significantly lower; we detected an average of 1.9 winter-resident birds per survey point on St. John compared to only 0.6 per point on St. Thomas (Askins et al., in press). Moreover, even the artificial habitats on St. John have a higher density of winter residents than similar habitats on St. Thomas. Degradation and fragmentation of natural habitats on St. Thomas have apparently resulted in a relatively low density of wintering migratory songbirds.

Maintenance of an abundance and diversity of wintering songbirds in the U. S. Virgin Islands will depend upon protection of the remaining tracts of moist forest, especially the relatively large tracts in Virgin Islands National Park. Some of these tracts, such as the upland forest on Bordeaux Mountain, are threatened by development on private land. A long-term threat is the pressure for road construction and recreational development along the south shore of St. John, where there are forested coastal basins.

Social Behavior of Wintering Songbirds

Our surveys revealed that wintering songbirds often occurred in mixed species flocks or aggregations. If participation in mixed flocks is important for wintering migrants, then forest fragmentation might have a negative effect on them if individuals become isolated and are unable to form flocks. To assess the distribution and frequency of mixed flocks, we surveyed transects in remnant patches of moist forest on St. Thomas and in larger moist forests on St. John (Ewert and Askins, 1991).

Most of the individuals detected in flocks (91%) were migrants. The two most abundant winter residents, Northern Parula (*Parula americana*) and Black-and-white Warbler (*Mniotilta varia*), were especially frequent in flocks. In contrast, only 17 percent of the flocks included permanent residents. Many of the groups of migratory birds moved together in a cohesive flock for more than 20 minutes, indicating that these groups were not merely chance aggregations at a favorable feeding site.

When we compared the frequency of flock participation and the size of flocks on the two islands, we found no significant difference. The average number of birds per flock (4.0 individuals of 3.1 species) was similar on St. John and St. Thomas despite the lower density of migrants on the latter island. Thus, there is no obvious relationship between habitat fragmentation and flocking behavior. However, survivorship of birds in flocks of similar size and composition may differ on the two islands. This requires further study.

Distribution of Resident Species

Unlike migratory birds, resident birds are more abundant in dry woodland than in moist forest (Robertson, 1962; Askins et al., in press). Although areas of dry forest are larger and more continuous on St. John than on St. Thomas, the number of species and individuals detected per survey point are similar on the two islands, indicating that habitat fragmentation does not have a major effect on either the density or diversity of resident birds. Hence, in this case the main concern may be the direct effect of habitat loss rather than to indirect effects caused by fragmentation of the remaining habitat.

Impact of Hurricane Hugo on Bird Populations

Hurricane Hugo hit the Virgin Islands in September, 1989. We visited St. John in January, 1990 to study the effect of the storm on bird populations. We completed surveys at 62 points in moist forest and dry woodland, compared to 90 points in these two habitats in 1987 (Askins and Ewert, 1991). The average number of individual permanent residents per survey point was significantly lower after the hurricane. Most of the species that showed substantial declines were species that feed primarily on fruit or nectar, a pattern that has been documented in several other studies of the impact of hurricanes on birds (Wunderle et al., in press). For example, Scaly-naped Pigeon (*Columba squamosa*), Antillean Crested Hummingbird (*Orthorhynchus cristatus*) and Bananaquit (*Coereba flaveola*) all showed significant declines. Most wintering migrants had similar densities before and after the hurricane, but the most abundant species (Northern Parula) showed a significant decline (Askins and Ewert, 1991).

Substantial declines of some resident bird populations after hurricanes indicate that island populations may be vulnerable to extinction, especially if their populations are already greatly reduced as a result of habitat destruction. The possibility of severe population declines due to hurricanes must be considered in any management plan for threatened or endangered species in the Virgin Islands. As much favorable habitat as possible should be protected for these species, with special attention to protection of sites with different exposures, elevations and slopes to allow for differences in susceptibility to hurricane damage.

Future Research

Permanent survey points have been established in Virgin Island NP to facilitate long-term monitoring. We plan to determine population trends in migratory song-

Continued on page 13

Water Quality Monitoring

(Continued from page 11)

Future Plans

We hope to continue the monitoring program to establish a sufficient database to assess long-term trends in water quality in the park. We also hope to start analyzing bacterial contaminants, in particular, fecal coliforms, for sites adjacent to coastal developments developments or heavily visited bays.

Giglia Beretta is a Biological Technician at Virgin Islands NP; Tobias formerly was a Biological Technician on the park staff.

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Seagrass Disturbances in Great Lameshur Bay, St. John

By Lisa Muehlstein

Seagrass habitats are extremely important components of coastal ecosystems; they stabilize bottom sediments and improve water clarity, exhibit high rates of productivity, and provide shelter and nursery grounds for many commercially important species. Seagrasses also serve as a direct food source for a number of different animals, most notably the green sea turtle (Dawes 1981, Zieman 1982). The seagrass communities in the Virgin Islands are subjected to many stresses, including pollution, development, recreational boating, disease and storms.

Great Lameshur Bay, St. John, has been the site of a multi-faceted seagrass study over the past three years, including the documentation of disturbances and the establishment of a long-term ecological study. This bay is within Virgin Islands National Park and Biosphere Reserve and receives less pressure from recreational use and development than other areas of the park. However, the seagrass community has been stressed significantly over the last three years.

Bluegreen Algal Overgrowth

In 1989, an unusual bluegreen algal overgrowth appeared in the bay following a tropical storm. In May, the overgrowth covered approximately one-third of the seagrass community and extended over the fringing reef along the western edge of the bay. In some areas, this bluegreen mat was 20-30 cm deep. A decrease in the vigor of the seagrass plants was apparent in these areas. Leaves were pale and senescing, apparently from lack of light and a decrease in available oxygen. The alga was tentatively identified as a species of *Schizothrix*. The cause of the overgrowth remains unknown. The tropical storm may have caused a flushing of the fringing mangrove system, releasing high levels of nutrients into the bay and stimulating the algal bloom. Hurricane Hugo wiped out the bluegreen algae, along with the overgrown seagrasses.

Hurricane Damage

During Hurricane Hugo, dislodged coral heads, tree trunks and other debris were carried into the seagrass bed by storm waves, leaving behind severely damaged plants. In many areas, seagrass plants were almost completely buried. In Great Lameshur, the seagrass bed was extensively damaged, with large blowouts reaching a maximum of 20 m by 20 m and up to 1 m deep. Several blowouts were marked after the storm to document recovery and succession within the seagrass bed. Measurements were taken on a quarterly basis to record areal change of the blowouts. Recovery of seagrasses could take several years partly because of extensive damage to the terminal meristems of the rhizomes (Fuss and Kelly 1969, Tomlinson 1974). Similar blowouts took 5 to 15 years to recover (Patriquin 1975). It took up to six months following the storm for sediments to begin to fill in the extensive pits. Fifteen months following the storm calcareous green algae including *Penicillus* spp. and *Halimeda* spp. began to colonize the bottom of the blowouts. This colonization may be the initial successional stage within a seagrass bed (Zieman 1982). However, the size of the blowouts actually increased as damaged seagrass plants continued to die back. Eighteen months after the storm, some new growth and colonization by manatee grass, (*Syringodium filiforme*) and turtlegrass, (*Thalassia testudinum*) was apparent. The size of the blowouts appeared to be stable, and no increase in area was observed. Twenty months after the storm, the blowouts appeared to be diminishing in size, reflecting more colonization by turtlegrass. Full recovery of the blowouts is likely to take several more years.

Disease

Disease is another stress affecting turtlegrass in Great Lameshur Bay. A pathogenic species of *Labyrinthula* has been isolated from turtlegrass in this bay as well as other bays around St. John, St. Thomas, and St. Croix. In laboratory tests conducted according to Muehlstein et al. (1988), the isolates of *Labyrinthula* have been conclusively demonstrated to be a pathogen of turtlegrass. Although no major disease-related declines have been documented in Great Lameshur or other local bays, the stress of disease is present and represents a threat to the habitat. Both temperate and tropical seagrass habitats have suffered major declines from disease over the last 10 years (Short et al. 1987, Muehlstein et al. 1988, Robblee et al. 1991).

Long-term Monitoring

In an effort to document the current status of the seagrass habitat and the effects of disturbance, a long-term monitoring project has been established in Great Lameshur Bay. Three 250 m permanent transects have been installed for the collection of basic ecological data. Measurements of seagrass density, community structure, and seagrass productivity have been taken at quarterly intervals for the last two years. Preliminary analysis indicates an unstable community structure with fluctuating populations of macroalgae, dominated by *Penicillus* spp. and varying densities of manatee grass and turtlegrass. Productivity is low in comparison to other areas. The instability of the community may reflect the level of disturbance over the last several years. It is extremely important to maintain a monitoring program, not only to document changes within the system but also to provide a solid data base for future resource management decisions.

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Migratory Birds in Virgin Islands NP

(Continued from page 12)

birds in relatively undisturbed habitats in the park. Consistent declines of migrants in these habitats would be evidence for an overall population decline, perhaps due to habitat changes in the breeding areas or on the migratory routes. At the same time, we can assess population changes of permanent residents, particularly rare or localized species. We also plan to expand our research on the ecology and behavior of particular species of wintering migrants.

Askins is an Associate Professor of Zoology at Connecticut College, New London, CT; Ewert is a biologist with The Nature Conservancy, East Lansing, MI. *Their research was supported by the National Geographic Society, the World Nature Association and the U.S. NPS.*

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letters

To the Editor:

As one who was lucky enough to be a participant in the Vail symposium, I read your editorial in the Winter 1992 issue with interest. I am in general agreement with the cautious optimism you expressed. Others, however, do not share this point of view.

Dr. Roderick Nash, one of the Service's most articulate critics yet ardent supporters, has expressed his disappointment in the recommendations of the symposium. He feels that the symposium participants missed the opportunity to articulate a strong National Park Service commitment to something Nash labels "planetery modesty."

Dr. Nash describes planetary modesty as a recognition that human beings are not the only passengers on Spaceship Earth. We must, Nash argues, live in harmony with nature because we have no more right to dominate nature than we do to dominate another individual. Aspens, canyons, periphyton, and all the other components of our ecosystem have a right to exist, not merely because of their value to us, but because they are an integral part of the world in which we all live.

This is revolutionary stuff – rocks have rights! – and the NPS is the perfect agency to pitch this vision to its visitors if only we have the courage to adopt it.

As is Nash, I am disappointed that we didn't take a stronger stand about the NPS and its potential role as a leader in resource stewardship. The Service seldom leads from the front. When was the last time we took a strong stand on major environmental issues such as overgrazing of public lands, irresponsible mineral development, or the failure to add to the nation's Wilderness Preservation System? When was the last time we told the ORV people to take a hike? We are going to be eaten alive by groups such as People for the West if we are not able to demonstrate where we stand, in stark contrast to what they are advocating.

Finally, quoting the environmental leadership section, while I applaud the concept of "leading by example," what examples are we going to demonstrate? We aren't progressive about recycling, we don't design for energy efficiency or site compatibility, we don't promote the use of alternatives to fossil fuels, we don't do much about getting visitors out of their cars, we favor commercial interests over private users in such areas as river permit allocations, we allow snowmobiles and outboard motors in pristine places such as Voyagers and Grand Canyon, we permit development in major resource areas, we spend more money fighting drugs than ARPA violations, we urge our superintendents to do more with less when we should have the courage to tell them to do *less* with less, and every year we lose ground in the preservation and protection of cultural resources.

It's not a pretty picture.

Rick Smith, Associate Regional Director
National Park Service Southwest Region

To the Editor:

The Winter 1992 issue of ***Park Science*** contained an editorial reporting excitement that the 75th Anniversary Symposium focused in a tough, no-nonsense, and very specific way on the need for organizational change in the NPS. Hope was expressed that real action will result.

There are good reasons to be hopeful, for top management is listening and the political system appears supportive of action. But Rome wasn't built in a day, and broad reforms will only come about over time. Just as ***Park Science*** urged its readers to get involved to shape the report, I would urge all employees to learn about the Symposium, become advocates, and look to participate directly in the implementation process now evolving.

The preliminary draft of the Symposium report contains major recommendations for reform and dramatic characterizations of agency problems. Describing the Service as "beset by controversy, concern, and weakened morale within," it reports that the Symposium "revealed a deeply disturbing sense that the nation is risking a deterioration of its natural and cultural heritage that not even the most dedicated personnel can effectively prevent." It observes that:

"Perceptions exist among many employees – and not without bases in reality – that good job performance is impeded by lowered educational requirements and eroding professionalism, that initiative is thwarted by inadequately trained managers and politicized decision making, that the Park Service lacks the information and research capability it needs to stand up for itself in Washington, DC, and in the communities that surround the park units, that the mission and the budget of the Service is being diluted by increasing and tangential responsibilities, that there is a mismatch between the demand that the park units be protected and the tools available when the threats to protection are increasingly coming from outside unit boundaries, and that communication within the Service repeatedly breaks down between field personnel and regional and headquarters management that lack or have no recent field experience."

It should be good news to your readers that the report states: "Science and research should form the foundation from which the NPS asserts itself as proactive leader." But, it observes, the Service is "extraordinarily deficient in its capacity to generate, acquire, synthesize, act upon, and articulate to the public sound research and scientific information." To remedy this, it recommends increasing the number of research and resource management professionals, a legislative mandate for research, and new funding.

The report also recommends expanding interpretation and educational outreach, revamping training programs, developing new human resource policies, and moving immediately to reform the park ranger series. Director Ridenour and Dep. Dir. Cables have begun organizing to act on the report, which is due in Washington about the time ***Park Science*** goes to press. A team of senior and mid-level field and Washington personnel has been appointed to propose strategies to implement recommendations, which must first be prioritized for action.

It appears certain that implementation will involve the use of many task and planning groups to develop the action strategies to address the issues. The Director's concept is to involve employees Servicewide in the effort. Team members will recommend these people, and I suggest you contact them and volunteer to participate. Team members are:

Bob Barbee, Maria Burks, Diane Dayson, John Debo, Mike Finley, Maureen Finnerty, Denny Galvin, Paul Haertel, Wallace Hibbard, Steve Kesselman, Ernest Ortega, Stan Ponce, Dick Powers, John Reynolds, Dick Ring, Rick Smith, and Kate Stevenson.

Dick Marks, Nancy Nelson, and I are providing staff support to the Deputy Director, who is leading this effort. We will help coordinate the groups and do what we can to keep things moving along. This is an exciting, hopeful moment in our history. We are receiving a high profile, prestigious document that calls for fundamental change to strengthen and expand the reach of this great organization. We have much to say about making it happen.

Loran Fraser
75th Anniversary Staff Coordinator

Editor's Note: For another slant on the Vail Conference, see the article by Bill Brown, retired NPS historian, in the current issue of the George Wright Society ***FORUM*** *(Vol. 8 No. 4).*

mab notes

Linkage between European and North American biosphere reserves across biomes will strengthen as a result of recommendations made at the meeting of representatives of EUROMAB in Washington, DC, Feb. 5-7. First a little background. These recommendations relate to the *EUROMAB Biosphere Reserves Integrated Monitoring Program*, known as BRIM. This program was launched at the August 1991 meeting of EUROMAB in Strasbourg. BRIM will provide the basis for:

Improving detection and prediction of trends in environmental conditions on continental and global scales; understanding the variability of natural and human caused phenomena and differentiating between the two; understanding the appropriate geographic and temporal scales of environmental problems; producing optimal spatial and temporal resolution and synthesis of information; testing hypotheses; and initiating processes of environmental learning and education.

The program will be carried out by establishing (1) a broad-based network of biosphere reserves that conduct basic inventory and monitoring of biological, physical, socio-economic, socio-cultural, and behavioral parameters; and (2) smaller, representative "subnetworks" for in-depth monitoring and research on special issues.

At present, 26 countries and 166 biosphere reserves are involved in BRIM. Nine countries – the U.S., Canada, United Kingdom, France, Germany, Sweden, and former USSR, Czechoslovakia, and Spain – were represented at the February meeting. In particular, the group recommended further consideration of NPS methodologies for biological inventory assessment and recording information on flora and fauna as a potential model for the EUROMAB program. Mike Ruggiero, Chief of the NPS Wildlife and Vegetation Division, will be working with representatives from Czechoslovakia and Sweden to adapt the NPS model for use in BRIM.

Other recommendations include creation of a EUROMAB directory, which will list contacts, facilities, and activities in the biosphere reserves; assessment of permanent plots in the BRs and development of guidelines for permanent plots; establishment of a pilot global change project in Europe; more emphasis on sociocultural factors at BRs, including case studies on making BRs work on the ground; and various organizational measures to strengthen EUROMAB.

NATO may be shrinking, but the environmental war dictates a growth in trans-Atlantic alliances like EUROMAB.

Napier Shelton
NPS Washington Office

Stream and Floodplain Restoration On Watersheds Disturbed by Mining

By Kenneth Karle and Roseann Densmore

Placer mining for gold has severely disturbed many riparian ecosystems in northern regions. Placer mining involves removing riparian vegetation and topsoil, excavating gravel from the active floodplain, old terraces, and/or the active stream channel, and processing the gravel to remove the gold.

Processing also removes most of the "fines" from the gravel. Until recently, topsoil and fines usually were buried under tailing piles or washed down the stream, and processed rock and gravel were left in large tailing piles. These tailing piles often revegetated very slowly – some more than 50 years old still have little or no vegetative cover.

Glen Creek, in the Kantishna region of Denali NP and Preserve (DENA), is typical of many placer-mined streams in the area. It is characterized by significant stream channel adjustments and disfunctioning riparian zones. Specifically, unstable or excessively confined streambeds, as well as over-steep floodplains, are evident along many reaches of the 6-mile length. Piles of mine tailings have replaced much of the native streambed material. Riparian vegetation is absent along most channel bank and floodplain reaches. Floodplain soils, necessary for vegetative recovery, are relocated in separate, distinct piles, or absent altogether. Soil replenishment, normally a function of annual flooding, is impossible because of confined streambeds.

The importance of a properly functioning riparian zone cannot be overstated. Riparian habitat in undisturbed conditions is characterized by greater species diversity, density, and productivity than any other habitat type. In addition to supplying the basic habitat needs of water, food, and cover, riparian habitat provides travel corridors and affects wildlife productivity in adjacent habitats.

Evidence indicates that the value of riparian habitat for wildlife in the Glen Creek watershed and other mined drainages of the Kantishna Hills is severely reduced where large amounts of riparian vegetation and soils are absent (USNPS 1990). Long-term habitat loss for grizzly bear, black bear, moose, furbearers, and birds has been documented. Additionally, aquatic zone habitat has been similarly disturbed. Populations of many of the macro and micro invertebrates, as well as slimy sculpin and grayling, are suspected to have been severely impacted or even eliminated.

With such a disturbed hydrologic regime, any riparian ecosystem recovery from placer mining in the Glen Creek watershed by means of natural processes is significantly hindered. In channel reaches where the streambed is incised and straightened, bed scouring continues to occur.

Brush bars for floodplain stabilization *may be seen on either side of the channel in this aerial view of the lower half of the 1991 study reach on Glen Creek in Denali NP.*

During annual flooding, erosion of over-steep banks results in excessive sediment loading of the stream. This sediment load is then deposited in the channel downstream in areas of shallower gradient, resulting in additional problems such as cementing of substrates and clogging of benthic invertebrates. Incised stream channels also prevent flood waters from reaching the floodplain, thus interrupting the natural process of floodplain sediment deposition necessary for enhancement and creation of moist, nutrient rich zones.

Feltleaf willow cuttings for revegetation *are shown here, along with brush bars for floodplain stabilization on a reclaimed section of Glen Creek.*

Pilot Study

Abandoned placer claims on lower Glen Creek represent a unique opportunity for conducting research to improve riparian habitat. A pilot study was begun in 1991 to evaluate techniques for rehabilitation of disturbed stream channels and floodplains. The study involved a 1400' reach of Glen Creek, and focused specifically on restoration of over-steep floodplains in that reach. The study's goal was to develop techniques to allow for the evolution of certain hydrologic characteristics such as sinuosity, pool/riffle ratio, and other natural habitat features with minimum construction needs.

Channel adjustments will provide for a streambed capacity to contain a 1.5-year flood, and a floodplain capacity to contain a 1.5- to 100-year flood. Sediment loading from bank erosion and other sources must be minimized. Channel controls, such as riprap or gabions, will not be used, as these generally hinder natural stream restoration.

Methods and Discussion

The BLM, in an attempt to enhance riparian zone recovery in a portion of Badger Creek, Colo., developed a scheme for designing stable channels in coarse alluvium based on pertinent geomorphic, hydraulic,

Continued on page 16

Dynamic Fire Modeling using GRASS 4.0

Developed by NPS and University of Arizona

By George Ball, Michael R. Kunzmann, & Peter S. Bennett

The use of Geographical Information Systems (GIS) for static modeling has been a major emphasis for implementation of GIS within the National Park Service. Linking dynamic models directly to existing NPS GIS data bases would provide the manager with the capability of examining "what if" scenarios that are directly related to the landscape area in question. The Advanced Resources Technology group at the University of Arizona in cooperation with the NPS Cooperative Park Studies Unit (CPSU/UA) have been examining the feasibility of incorporating these dynamic GIS programming linkages to existing fire behavior and effects models. A primary goal has been to provide a set of user-friendly GRASS 4.0 programming tools that can extend the range of park management analysis opportunities.

GRASS 4.0 Fire Modules

The Advanced Resource Technology Program at the University of Arizona has been developing, modifying, and adapting modeling extensions to the GRASS 4.0 programming environment. The program modules or processing extensions are collectively known as PROMAP and were developed by **Ball (1990)** to examine complex dynamic modeling as an extension of Geographical Information Systems and related technologies (e.g. resource management computer information and retrieval systems).

Spatial dynamic modeling requires algorithms and data storage that are consistent with iterative processing. The PROMAP programming operators use integer or real numbers depending on the type of operation and function being performed. Storage of integer information is in the standard GRASS format while the real number information is stored as a simple binary file. The modules that have been developed are shown in **Table 1**. The modules are compiled as contributed programs in the same manner as other GRASS functions.

In addition to the basic operations, two specialized modules have been developed for use in fire spread modeling. As an example of spatial dynamic modeling in GIS we will examine the fire simulation model known as FIREMAP (**Vasconcelos, et. al., 1990; Ball and Guertin, 1990**).

FIREMAP is based on the fire equations of **Rothermal (1972)** and the BEHAVE program of **Andrews (1986)**. In producing a fire growth simulation the GIS is used to develop the base maps for fuels, slope, aspect, moisture and other fire parameters. Once the base layers are constructed, the PROMAP programming modules called "Sbehave" and "Sfire" are used to produce the simulation. The first module calculates the fire characteristics for all the cells in the data base. The Sbehave module produces two files as standard output. These files represent the rate of spread, the midflame wind speed, and the direction of maximum spread. The second and third parameters as combined into a single file. The files, "hros" and "windms" respectively, are used as the input to the fire modules.

Figure 1

Figure 2

Stream Restoration *(Continued from page 15)*

and hydrologic principles (Jackson and Van Haveren, 1984). This scheme is based on the premise that a channel in coarse alluvium is considered stable if design discharges and sediment loads can be carried without causing excess bank or bed erosion or deposition. This design, with modifications for subarctic conditions, was the basis for the **1991** pilot study.

An important aspect of this channel design scheme is consideration of the process of adjustment from the initial stable channel geometry in noncohesive materials to the final regime geometry. When streamflow or sediment loading rates increase, channel widening may be expected to occur.

However, channel depth decreases with an increase in sediment loading rates. When conditions that have caused channel impacts such as widening and depth reduction begin to abate, and riparian zone revegetation begins to occur, the channel should begin to adjust itself toward a narrower, deeper geometry. Therefore, any design should plan for and incorporate this modification.

The central channel design is based upon a capacity to transport the bankfull flow of more stable reaches in the same setting. Incipient bed instability should be attained at bankfull flow, allowing upstream bed material to pass and enabling channel geometry to adjust to bank revegetation. Bankfull discharge may be considered as the 1.5-year flood.

Floodplain design objectives include a capacity for the 100-year flood. With this parameter, the floodplain should act to dissipate high water flow energy while encouraging deposition of sediments for vegetation habitat enhancement. Ideally, the floodplain design should minimize earthwork and expense while approximating, as closely as possible, a natural or stable channel flood plain condition.

Once the design parameters for channel banks and floodplains were calculated, preparation work began on the ground along a 1400′ reach. Design elevations and distances were surveyed and staked, and a crawler-dozer, front-loader, and dump truck were employed to move the ground to the desired configuration. Where the stream channel was incised, the adjacent floodplain was cut back and lowered, with the excess material graded into the slope of the valley wall. Additionally, flat braided sections were filled in, encouraging a single channel. The floodplain surface was roughened by the dozer to retard erosion and capture fines.

Undisturbed floodplains in the Kantishna area are stabilized by riparian vegetation (primarily feltleaf willow (*Salix alaxsensis*) and alder (*Alnus crispa*), which anchors the substrate and decreases the velocity of floodwaters. The drop in water velocity accelerates the deposition of sediment and organic debris.

Several methods are being tested to temporarily stabilize the new floodplains until natural revegetation becomes adequate, which is predicted to take 5 to 10 years. Methods include well-anchored brush bars 15 to 20 feet long, oriented perpendicular to the channel. Bars are constructed of alder branches tied in bundles, partially buried and spaced at intervals of three channel widths. Streambank plantings of feltleaf willow cuttings and alder seedlings also have been established.

A comprehensive hydrologic monitoring effort was enacted, the objective being to evaluate the current "health" and recovery status of Glen Creek following channel and floodplain reclamation. Cross-sections were established for sampling selected parameters above, in, and below the reclaimed reach. Parameters sampled include suspended sediment, stream chemistry, and biological communities. Stream discharge measurements were made at all sampling times. Effects of stabilization techniques will be evaluated by monitoring floodplain morphology, sediment deposition, and natural revegetation on floodplains with and without stabilization.

Future Studies

In order properly to evaluate the effects of an active reclamation effort on a disurbed stream channel and floodplain, a much longer reach of stream channel is needed. Funding from NPS-WRD (Water Resources Division) will allow an adjoining 3200′ reach to be included in the study. Additional techniques will be tested on this section during the **1992** season, including some channel reconstruction. This study, combined with the **1991** pilot study, will serve as a demonstration project for other mined stream reclamation efforts in DENA and other areas of Alaska.

Karle is Hydraulic Engineer at Denali NP; Dr. Densmore is Denali Park Ecologist.

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The fire module defaults to a 3x3 window to determine what cells have the potential to be ignited. The algorithm takes into account vector information (aspects as whether the fire will be entering as a head fire or as a flanking or backing fire). As a consequence, the modeled fire spread is a result of fire characteristics as well as terrain and fuel heterogeneity. **Figure 1** illustrates the results of fire growth over uniform terrain and with uniform fuels for a wind driven fire. **Figure 2** illustrates the results with the use of uniformly random fuel moistures.

Testing of LD_{50} GIS Model

As part of the field evaluation and testing program for the FIREMAP simulation we have been working with a Grand Canyon data base. The availability of fire data and statistics from Point Sublime, Grand Canyon, as modeled by **Kunzmann, Bennett, and Ball (1990)** for a Species Lethal Diameter Class Fire Mortality Model (at 50% class mortality; **Figure 3**), as abbreviated LD_{50}, has provided a starting point to estimate ecological fire effects for 4 species of coniferous trees.

The LD_{50} data provides a quantitative data for fire intensity vs. species diameter for the fuel models on the North Rim of Grand Canyon National Park. Running simulations based on average meteorologic data and information collected by Kunzmann and Bennett, we have begun to examine how well the model relates to the measured conditions. Testing is still in the preliminary stages and we have been examining other potential sites for subsequent testing.

Discussion

In general, higher resolution DEM data, georeferenced site data and maps are requirements for spatial dynamic modeling. For example, the use of 200 foot contours does not provide sufficient resolution for most fire spread models. A Grand Canyon data set using available 200 foot contour data makes the North and South Rims appear very flat thereby reducing the effect of landscape factors which can play a major role in fire spread. Furthermore, the specific type of DEM algorithm utilized can significantly effect the results obtained even in the simplest viewshed analyses (**Christofferson, Potter, Guertin, & Kunzmann, 1991**). Greater emphasis must be placed on obtaining better georeferenced information for site data and historical fire patterns. Better georeferenced site and DEM data are required to test modeling assumptions and computer algorithms. Quantitative evaluation and validation of site information are prerequisites to assessing the precision and accuracy of GIS computer models.

Directly related to fire, there are problems that need to be addressed in some of the current analytical programs being used such as the BEHAVE system. BEHAVE was not intended for use in computer simulations and therefore algorithms need to be adjusted to make them more useful in a GIS environment. At the University of Arizona, modeling adjustments are being tested and enhanced wind profile and fuel models are being incorporated into the GIS GRASS environment.

Other resource applications of spatial dynamic modeling include: watershed problems such as erosion, sediment transport, and water quality. The analysis of traffic patterns, usage levels and other temporal problems are also possibilities for this type of modeling. For more information concerning PROMAP contact George Ball at the School of Renewable Natural Resources at the University of Arizona or Mike Kunzmann at the CPSU/UA.

Ball is a Research Specialist on the U/AZ faculty; Kunzmann is an Ecologist and Bennett a Research Scientist at the U/AZ Cooperative Park Studies Unit.

Table 1. PROMAP - GRASS Operators

Operator	Function
Sbool	Performs boolean operations
Scode	Reclassify values on a map
Sdrain	Find drainage paths over a terrain surface
Smath	Perform mathematical calculations using maps as input
Smm	Minimize or maximize values on a series of maps
Spoint	Change values at specific locations or block areas
Sscan	Analyze the attributes of a neighborhood
Sslice	Create interval map from continuous data
Ssprd	Propagate values from a source
Sterr	Calculate slope, aspect and ridge lines from DEM
Sview	Performs viewshed analysis
Sbehave	Specialized operator for calculating fire characteristics
Sfire	Specialized operator for simulating fire growth

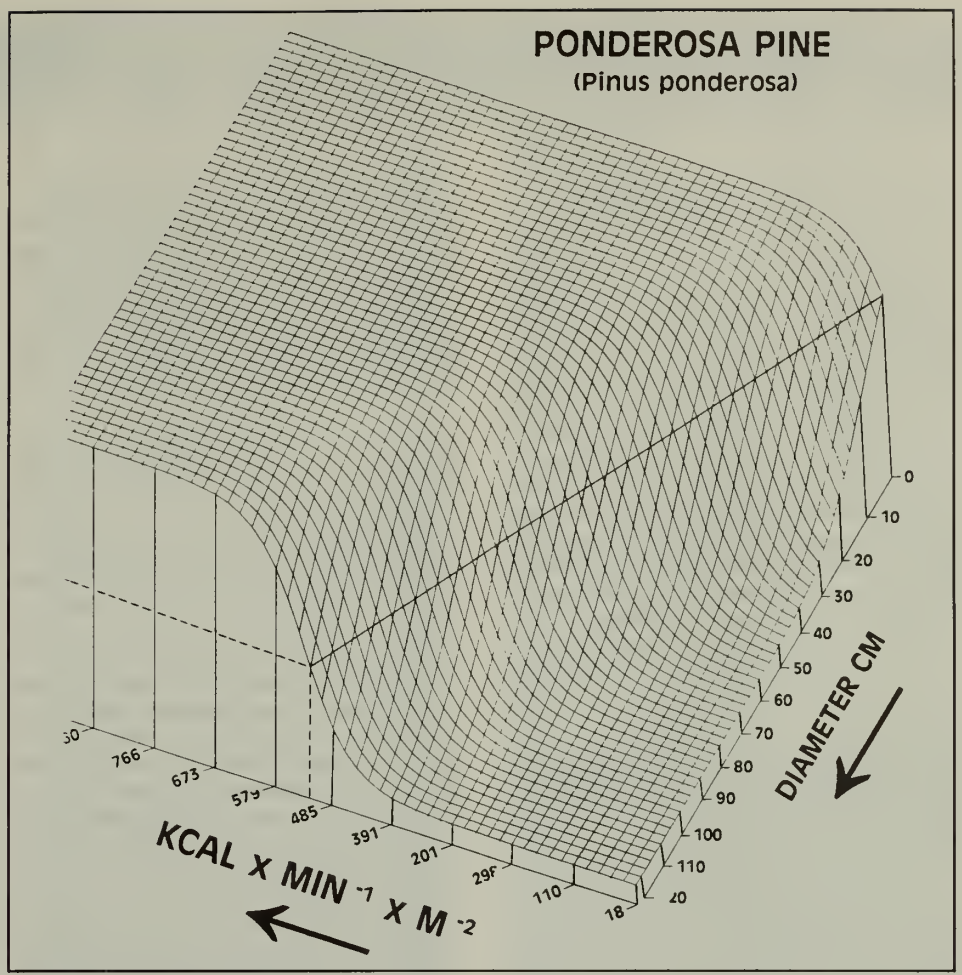

Figure 3. LD_{50} Mortality Probability

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Note: The PROMAP code is listed as a SUN CATALYST product and is available free of charge to interested researchers. It is a research grade programming tool and should be used as such. The use of PROMAP is encouraged for the development of end user applications. It has been developed and runs on SUN SPARCstations and should run on all UNIX based computer platforms. There is no display capability built into this software as of this date and PROMAP documentation is preliminary.

publications

After the Ice Age: The Return of Life to Glaciated North America, by E. C. Pielou (1991 University of Chicago Press, 366 pp. ISBN 0-226-66811-8).

Less than 20,000 years ago nearly all of Canada and the northern tier of the U.S. was covered by an expanse of ice about the size of Antarctica. Pielou's masterful synthesis of geological, palynological, and biogeographical information provides a vivid account of the transformation of the continent that occurred as the ice melted. She also provides useful instruction about the limitations of different sources of information (e.g. pollen diagrams) and clearly presents opposing arguments on several controversial scientific issues – whether or not a "mammoth steppe" occupied Beringia, the time and route of colonization of the continent by humans, and the much discussed possible role of man in the extinctions of large mammals. The book is natural history at its finest, and should be required reading for NPS scientists and naturalists.

Doug Houston, Wildlife Ecologist
Olympic NP, Port Angeles, WA 98362

* * *

Our Changing Landscape: Indiana Dunes National Lakeshore is the title of U.S. Geological Survey Circular 1085, edited by Catherine Hill, Barbara Ryan and Bonnie McGregor for the USGS and Marie Rust for the National Park Service.

Following a joint Foreword by USGS Director Dallas Peck and NPS Director James Ridenour are 45 spectacular, color-drenched pages – a photographic essay on some of the environmental challenges facing Indiana Dunes. "The earth-science issues facing Indiana Dunes mirror national issues faced by other parks and public lands," the Foreword states, and then continues wtih a quote from Francis Bacon: "Nature, to be commanded, must be obeyed."

The issues described in this essay include global change, land use, wetlands, coastal erosion, and contamination. The publication is free on application to the Books and Open-File Reports Section, USGS, Federal Center, Box 25425, Denver, CO 80225.

* * *

A Heritage of Fishing: The National Park Service Recreational Fisheries Program, edited by Lissa Fox with graphics by Mark Stephen Hall, is a handsome, 20-page, full color publication describing NPS participation within a National Recreation Fisheries Policy framework. In June 2988, the NPS and more than 60 federal, state, and private organizations signed such a policy, to provide long-term common goals for managing the nation's recreational fisheries. The booklet describes many of the recreational opportunities involving fishery resources currently available in park units, and oautlines future actions to improve and enhance the Service's fishery resources.

Copies are available from the NPS Wildlife and Vegetation Division, PO Box 37127 MS 490, Washington, DC 20013-7127

* * *

State of the World: 1992, the annual report of the Worldwatch Institute on progress toward a sustainable society, is out and being met with even more than the usual enthusiastic reviews. The ***Wall Street Journal*** describes it as "a runaway bestseller." With worldwide sales topping 300,000 and available in 26 languages, this book is used by policymakers at all levels of government and by corporate managers and planners all over the world. It is required reading in more than 1,300 courses in nearly 700 U.S. colleges and universities. ***Science*** magazine observes: "It points us wisely ... toward a much stronger and better-supported interdisciplinary monitoring of indicators that bear on the chances for progressing toward a sustainable society."

Paperback editions are $10.95 for one, $7.95 for 2-4 copies, and $5.95 for 5 or more copies, from Worldwatch Institute, 1776 Massachusetts Ave., N.W., Washington, DC 20036-1904.

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From Jill Baron, Research Ecologist with the NPS Water Resources Lab at Colorado State University in Fort Collins, comes word of a new book, presenting the Loch Vale Watershed study.

Biogeochemistry of Subalpine Ecosystem: Loch Vale Watershed, 1991/approx. 240 pp., 90 illus./ Hardcover $89.00/ISBN 0-387-96705-1 (Ecological Studies, Vol. 90).

Published by Springer-Verlag and edited by Dr. Baron, with a Foreword by Jerry Franklin, this study increases understanding of natural biogeochemical pathways and the effects of acidic deposition in the alpine and subalpine environment of Rocky Mountain NP. The study characterizes precipitation, bedrock, soils, lakes and streams, aquatic organisms, and woody vegetation. It attempts to quantify major elemental and pollutant flux, and identifies sources, sinks, and controls of important ions.

Among the topics addressed in this synthesis are sources and seasonal variations in acidic deposition, buffering of surface waters through soil processes, geochemical mass balance, the chemical composition of surface waters, nutrient and growth dynamics of old-growth spruce-fir forests, and some methodological considerations.

A major objective of the Loch Vale Watershed study was to show the validity of ecosystem analysis as a resource management tool that allows quantitative assessment of the effects of human activities on natural systems. This book then is of interest both to researchers studying these processes and to managers concerned with potential loss of ecological integrity.

The book may be ordered from Springer-Verlag New York, Inc., P.O. Box 2485, Secaucus, NJ 07096-9812, add $2.50 for postage and handling; or call toll-free 1-800-SPRINGER between 8:30 am and 4:30 pm Eastern Time, weekdays.

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From Doug Wilcox, now with the USFWS National Fisheries Research Center-Great Lakes, at Ann Arbor, MI, comes a reprint from the ***Canadian Journal of Botany*** (Vol. 69:1542-1551). The article, co-authored with James Meeker of the U/WI botany department, is titled "Disturbance effects on aquatic vegetation in regulated and unregulated lakes in northern Minnesota," and represents some results of the work Wilcox did while he was on the staff of Indiana Dunes National Lakeshore.

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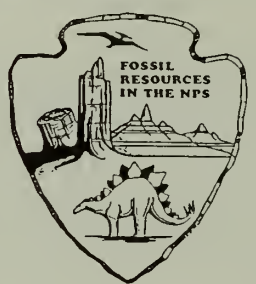
Park Paleontology is the title of a newsletter that first appeared in January 1991, edited by Vincent L. Santucci (now paleontologist/curator at Petrified Forest NP) and aimed at furnishing paleontological information to the many NPS units with such resources. Santucci explains that paleontological resource management, protection, and interpretation strategies have developed rapidly over the last decade, with only a handful of paleontologists employed by the NPS to assist the many parks that lack staff trained in paleontology and in developing fossil management strategies.

Five issues later, ***Park Paleontology*** now is a quarterly, serving 70 NPS units with recognized fossil resources. Overwhelming interest has widened the focus to include any federal, state, or other agency that manages, protects, and interprets paleontological resources, and whose personnel are interested in sharing ideas and techniques for management of fossils on public lands.

Scope of the newsletter includes (1) announcement of new fossil discoveries; (2) description of paleontological research and management of this research at NPS and other sites; (3) tools and techniques for interpretation of fossils and related topics such as geologic time, evolution, etc.; (4) new exhibits or displays related to fossils; (5) ideas related to use of professional paleontologists for training park staff, providing curatorial assistance, identifying sensitive resource areas, etc.; (6) curatorial techniques related to fossil collections, and (7) law enforcement concerns regarding protection from vandals or theft of paleontological resources. Contact: Vincent Santucci, P.O. Box 2266, Petrified Forest, AZ 86028.



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The Fire Research Institute, PO Box 946, Roslyn, WA 98941-0946, publisher of the ***International Journal of Wildland Fire***, ***The International Bibliography of Wildland Fire***, and ***The International Directory of Wildland Fire***, is beginning a new publication – ***Bulletin of the Fire Research Institute***. The bulletin will list, on a monthly basis, any new journal and newsletter articles on the subject of wildland fire, together with an abstract. For more information, call (509) 649-2940; Jason Greenlee, Director.

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Jurassic Park, by Michael Crichton. Ballantine Books, New York. 1990.

Ian Malcolm, one of the characters in *Jurassic Park*, says: "Discovery is always a rape of the natural world. Always."

My mind wandered a bit from the story when I read that line on page 284. My mind's eye focused on Columbus and others who conducted trips of "discovery." I asked myself what are the real cultural, social, and biological ramifications of these expeditions? ***Jurassic Park*** is not a story about an expedition, but it does present a set of fictional conditions that could be profitably noted by many, especially those managing natural ecosystems.

Power and influence have driven some mighty events, and these driving forces are behind the coming-into-existence of the fictional Jurassic Park. In the book, money buys specific technology, knowledge, and isolated space for a park that features cloned dinosaurs.

Continued on page 19

notes from abroad

By Rick Smith
NPS Southwest Region Associate Director

The call from Rob Milne, Chief of the Office of International Affairs, was unexpected.

"Is it true that you and Kathy are going to Honduras on annual leave?" When I reponded affirmatively, he countered with another question.

"Would you consider going a week earlier to follow up on Secretary Lujan's recent visit to Honduras?" He went on to relate that the Secretary had stopped in Honduras on a swing through Central America. He had promised Honduran officials that agencies under his supervision would visit the country to explore potential partnerships with Honduran conservation agencies. It would be my task, Rob explained, to examine whether there were ways the National Park Service could aid our colleagues in Honduras. Since any trip to Latin America is inevitably interesting, I eagerly accepted. I was not disappointed.

By developed country standards, Honduras is relatively poor. Slightly larger than Tennessee, it shares boundaries with Guatemala, El Salvador, and Nicaragua. The 5+ million people enjoy a subtropical climate in the lowlands and a temperate one in the mountains. The country is mostly mountainous in the interior, with narrow costal plains. Agriculture is the most important sector of the economy, accounting for nearly 30 percent of the GNP, employing 62 percent of the labor force, and producing two-thirds of the exports. As with many developing nations, Honduras faces the issues of a high population growth rate, estimated to be 3.1 percent, a high unemployment rate, a lack of basic services, a large public sector, and an over-dependence on exports such as coffee and bananas, which are subject to sharp price fluctuations.

During my official stay in Honduras, I visited 4 protected areas and added a fifth while on annual leave. What I saw was absolutely amazing. Our first stop was Copan, a World Heritage Site. Copan is nothing short of breath-taking. Nestled in a fertile valley, the site is testimony to the genius of the Mayans. Archeologists have studied the site in detail and much has been excavated and stabilized. These experts speculate that as many as 30,000 people may have lived there in 800 AD. If true, this would make Copan one of the largest urban centers in the world at that time, certainly larger than anything in Europe. Perhaps only urban centers in Asia would have been larger.

In a story that would not be unfamiliar to Southwestern archeologists, the collapase of Copan in 900 AD is thought to have been the result of an expansion by the urban community into the rich agricultural areas, moving the agricultural base of the city up into the marginal lands on the nearby hillsides. Since the community was no longer self sufficient, the rulers had to share power with others who could supply the population with the necessary food. This power sharing led to the diminishment of the rulers'authority and eventually to the abandonment of Copan. The site boasts a visitor center, an arts and crafts shop, a small restaurant, bilingual guides, and an entrance gate to control visitation. As the most famous tourist attraction in Honduras, it is well maintained, administered by the Honduran Institute of Anthropology and History, a semi-autonomous government organization.

Our next stop was at Cuzuco NP. We left early one morning, climbing straight up 2,000 meters out of San Pedro Sula on a dirt road. Even with four wheel drive, we managed to get stuck in one place. The climb passes through several life zones and gives a fascinating look at the changes civilization is bringing, not only to the people, but also the environment. It is almost like the rite of passage ones goes through going from Key West to Fort Jefferson National Monument. The visitor begins in San Pedro Sula, the entrepreneurial capital of the country, an example of our 20th century civilization, climbs out of the city, leaving the 20th century behind, and passes through small villages and clusters of huts, most of which do not even have electricity.

At the village of Buenos Aires, I would recommend that all vehicles be required to stop and that the tourist make the rest of the trip, some 4-5 kilometers, by horse or mule. The villagers in Buenos Aires should be given the opportunity to offer modest services such as guiding, mule rental, food, etc. This would make them supporters of the park because they would have an economic interest in its preservation. The passage from the 20th century would end in Cuzuco NP, a slice of what Honduras looked like prior to arrival of the Spanish in the 16th century.

Cuzuco is a smallish rainforest park, some 10,000 ha. The park's only infrastructure currently is a small visitor contact station, without electricity. Plans for the park call for construction of small huts where visitors could stay overnight for a modest fee. What they would see while there is the astonishing biodiversity. During the time I wandered in the park, it occurred to me that I could not name one living thing.

The Honduran Forest Service administers the park and has in place one unique management strategy I believe could be profitably adopted by the NPS. In the middle of the park, they have established what they call a *zona intocable*, an untouchable zone. No one is allowed to go there, no visitors, no administrators, and no scientists. The concept is that it will serve as a control point to measure the pace of change in the rest of the park caused by visitation. Wouldn't it be great if we could establish such zones in some of our great wilderness parks in Alaska or in the West?

From Cuzuco, we went on to La Fortaleza de San Fernando de Omoa, an 18th century Spanish fort on the northern coast. The Spanish constructed the fort to protect a nearby harbor. The Hondurans were involved in an historic preservation project at the fort, and their efforts reminded me of many of the preservation problems at our coastal parks.

Our final stop was the Lancetilla Botanical Gardens. Although threatened by nearby development, the Gardens contain a representative sample of the native species of Honduras and a demonstration of the exotic species that have been brought to the country over the years by agricultural or business experts. There is the thought that the gardens represent a kind of genetic warehouse for the native species of the country. If any type of restoration ecology ever became feasible, the gardens would serve as seed sources.

The trip provided a fascinating look at the conservation issues facing a Central American country. All the official representatives with whom I met were appreciative of the interest Secretary Lujan is demonstrating in Honduras. They hope for close cooperation between the bureaus of the Department and the Honduran government. I see several areas in which I believe the NPS could assist. I propose that we consider establishing a system of "sister parks" for some of the protected areas within Honduras. The staff in the sister parks could provide technical advice, exchange information, and provide an avenue for our visitors to get to know the parks of another country. Any one of our coastal forts, for instance, faces many of the same issues that face the staff at Omoa. Our archeological parks share issues with Copan. Natural areas have much in common with Cuzuco. I remember that the Peace Corps used to administer a similar program with schools, called, as I recall, the School Partnership Program. Maybe we could get the Peace Corps to establish a similar program with parks.

Also, we could provide assistance in the country's environmental education program. It is absolutely certain that the success of any conservation efforts in Honduras will revolve around changing peoples' attitudes toward unchecked exploitation of natural resources.

There also are possibilities for technical advice and assistance in areas such as interpretation, protection, and resources management. I saw, as an example, several things during our visit to the restoration project at the fort that bothered me. I'm sure a good historic architect could make useful suggestions. Our archeologists could assist in establishing processes for field investigations and data collection and recording. Aside from the guides at Copan, I saw no attempt to interpret park resources to any visitors who might show up at a protected area. Finally, there is a critical need for coordinated planning for park areas. I reviewed, for example, the goals and objectives for Cuzuco. I did not feel there was enough emphasis on consulting with local people or the other agencies that will have to cooperate if the park is ever going to be open for visitation.

Publications *(Cont. from p.19)*

The project, with its exotic cast of prehistoric characters, is held close to the power brokers' chests. Those who provide general knowledge about the animals and their behavior are kept in the dark as much as possible.

A meeting of the power brokers and those knowledgeable about the animals, held at the island park, is the setting for events that demonstrate the impossibility of "control" on the part of the perpetrators. Once natural events are set in motion – even in the most unnatural ways – the question rapidly degenerates from one of control to one of mere survival.

Ian Malcolm and Dr. Grant are characters who grab and hold your interest as the exciting plot unwinds. Malcolm's intellect and Grant's broad knowledge are consistent reminders that all societies need a healthy mix of raw intelligence and educated thought as we continue our search for understanding our world.

If you are a regular reader of world and environmental issues, this book will help you focus beyond the specifics. We are part of a larger scheme – one which simply may not be comprehensible, but one which is not necessarily totally chaotic.

To quote Ian Malcolm: "It's a matter of what you think you can accomplish. When the hunter goes out in the rain forest to seek food for his family, does he expect to control nature? No. He imagines that nature is beyond him. Beyond his understanding. Beyond his control. Maybe he prays to nature, to the fertility of the forest that provides him. He prays because he knows he doesn't control it. He's at the mercy of it... Your power are much less than your dreams of reason would have you believe."

R.J. Valen, Chief of Interpretation
Guadalupe Mountains National Park

regional highlights

Editor's Note: *We* ***love*** *Regional Highlights! But eventually we could fill the entire issue with them. Because our space is limited, we must ask that all Regional Highlights be routed through the Regional Chief Scientist (or the designated purveyor of Highlights for the Region) and that he/she be responsible for making them as brief as possible (while still getting the messages across) and RANK them in the order of importance, in case we still must cut. Thank you so* ***very*** *much.*

Pacific Northwest

Bull trout, once found in most major river systems in the Pacific Northwest and Canada, have lost ground (or water) over the past 30 years, and many local extinctions have occurred. The Klamath River Basin, Oregon, populations are genetically distinct from other Pacific Northwest populations and are now restricted to cold headwater streams. Habitat degradation and introduction of non-native species are believed the primary causes for the recent decline. Bull trout have been listed as a candidate species under the Endangered Species Act by the USFWS, and as sensitive species by the State of Oregon.

Crater Lake NP has developed a bull trout management program to remove introduced brook trout from Sun Creek in the park, build a barrier to prevent re-invasion, and re-establish a self-sustaining population of bull trout in Sun Creek to the park boundary. No management action will be taken until an Environmental Assessment by an interagency team of experts is produced and made available for public comment.

Mark Buktenica, the park's aquatic biologist, will furnish ***Park Science*** with an article on the management program in a future issue.

Bull Trout *Reproduced with permission of J. Tomelleri*

Southeast Region

Dr. Stephen V. Cofer-Shabica, oceanographer, has been named Director of the NPS/CPSU at the University of Georgia following the departure of Dr. Susan Bratton.

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Skip Snow, Resource Management Specialist at Everglades NP, participated in a USFWS-sponsored technical workshop on the Florida manatee population biology in Gainesville Feb. 4-7, 1992. Seventy participants provided information on manatee biology and ecology to an invited panel of 10 population biologists and statisticians, including such notables as Lee Eberhardt of Battelle Labs, Douglas DeMaster of NMFS, Charles Fowler of Alaska Fisheries Science Center, James Nichols of USFWS, Robert Garrott of U/WI, and Helene Marsh, dugong researcher from James Cook University, Australia.

The panel was charged with making recommendations on how to improve our knowledge of manatee mortality and survivorship, population estimation and trends, and estimates of growth rate and development of simulation models. One recommendation was to establish a Manatee Aerial Survey Working Group. Snow was selected as a member of this group. Workshop proceedings will be made available in coming months.

* * *

Everglades Resource Management Specialist Skip Snow and pilot Dave Dutcher participated in the 1991-92 Florida Statewide Synoptic Manatee Aerial Survey Jan. 17-18, 1992, by contributing aerial survey results from the park's entire coastline and mangrove zone. Conditions were near perfect and a record 1,856 manatees were counted statewide.

Within Everglades NP and the adjacent upper Florida Keys, 106 manatees were counted. Despite the high count (1,856), the true population size remains unknown, and there is no reason to believe that manatees are less endangered than before or that we should halt any ongoing manatee conservation strategies. The record numbers of documented deaths in recent years remain a major impediment to the species' recovery. More manatees died from human-related causes (68) in 1991 than ever before. Likewise, more small ("perinatal") calves died (53) than ever. Statewide, continuing levels of habitat loss and degradation, as well as possible water pollution, also are serious ongoing concerns.

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The CPSU at U/TN is expanding. A search is underway for a second research ecologist, to join Stephen Nodvin, who has been the only NPS scientist on staff since 1988. John Peine also has been added to the staff as Research Social Scientist.

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Nodvin has submitted two proposals to the Cooperative States Research Service through U/TN toward developing new research in the Great Smoky Mountains NP. He worked with Dr. Helga Van Miegroet of Oak Ridge National Lab (ORNL) in developing the proposal: "Nitrogen Dynamics and Nitrate Export in Southern Appalachian Forests" to evaluate the importance of ecosystem and geographic factors such as forest age and disturbance and stand elevation in regulating the export of nitrogen and other nutrients from forests at Great Smoky Mountains NP.

Nodvin also worked with Henriette Jagen, also of ORNL, in developing a proposal entitled "Multivariate Spatial and GIS Techniques to Monitor and Map Water Quality." which, if funded, would incorporate available stream quality data, new GIS data, and new multivariate techniques to develop water quality maps for streams at Great Smoky Mountains NP.

Nodvin and his CPSU staff are developing an indexed bibliography of references for Great Smoky Mountains NP – a database of primarily scientific references which now contains approximately 1800 records. Office Asst. Susan Twigg and Nodvin are indexing the references and plan to have a printed draft ready for review by this summer.

Midwest Region

In 1991, a joint NPS/Wisconsin DNR pilot study was conducted to develop methods for identifying the causes of bald eagle nest failure at Apostle Islands National Lakeshore. Data collected support the hypotheses that weather, contaminant exposure, and prey availability all may impact the Apostle NL bald eagle population. Primarily as a result of this study, a $320,000 proposal to continue and expand the project was funded by the Great Lakes Protection Fund. The expanded study will include behavioral work by NPS, Wisconsin DNR, the U/WI, and the USFWS, plus toxics analyses by MI/State/U.

* * *

A rare plant inventory at Apostle Islands NL was begun in 1991. Three endangered and 12 threatened plant species on the Wisconsin State List of Threat-

The long-awaited recovery plan for the northern spotted owl is nearing completion by an 18-member recovery team. The owl, which was listed as threatened in July 1990, has been the center of a controversy over management of Pacific Northwest forests for nearly 20 years. This medium-sized bird inhabits late successional forests, commonly referred to as "old-growth forests." These forests have enormous economic values; thus, a conflict exists between those who wish to harvest timber and those who would preserve old-growth habitats.

Northern spotted owls are found in several areas of the National Park system, however Olympic NP and Point Reyes National Seashore are especially critical to the species. The southernmost breeding pairs are located in forested areas of Point Reyes, just north of San Francisco, and they may be reproductively isolated from other pairs by residential development as well as natural grasslands.

Low and mid-elevation forests of Olympic NP provide a core of habitat for the remaining spotted owls on the Olympic Peninsula of Washington State. The park contains most of the remaining unharvested forest on the peninsula, and this population of spotted owls also may be reproductively isolated.

The recovery plan is based on a conservation strategy for the northern spotted owl which was developed in 1990 by the Interagency Scientific Committee chaired by Jack Ward Thomas. Doug Houston, Pacific Northwest Regional research biologist, played a major role in formulation of this strategy. Ed Starkey, research biologist with the NPS CPSU at Oregon State University, is a member of the recovery team.

The plan proposes that, on federal lands, suitable habitat be provided for clusters of owls distributed across their range. Although no commercial harvest would be permitted within these habitat areas, the areas would be surrounded by a matrix of forest lands on which a wide range of timber management activities would occur. However, matrix lands would have to provide habitat that would at least allow spotted owls to move freely between clusters.

Following public and agency review of the draft recovery plan and any needed revisions, the proposed final plan will be reviewed by the Secretary of the Interior. If the recovery plan is approved by the Secretary, it would provide guidance for federal agencies as they develop action plans for management of the northern spotted owl.

ened and Endangered Species were known to occur in Apostle Islands NL prior to 1991. Two additional State endangered species found in the 1991 study were *Salix cordata* and *Armoracia aquatica*, and significant new localities were discovered for *Pinquicula vulgaris* (State endangered), *Trisetum spicatum* (State threatened), and *Salix planifolia* (not listed). Unsurveyed portions of the Lakeshore will be surveyed in 1991; inventory results will include rare species locations and descriptions, habitat requirements, recommendations for protection, and monitoring protocols, plus a published flora for the Lakeshore.

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The USFWS has published a proposed rule in the ***Federal Register*** to list the Karner blue butterfly (*Lycaeides melissa samuelis*) as an endangered species. Its habitat is characterized by the presence of wild lupine (*Lupinus perennis*,) the only known larval host food plant and thus closely tied to the butterfly's ecology and distribution. Habitat is typically grassy openings within dry sandy pine/oak barrens or oak savannas. Periodic disturbance is required to maintain open areas supporting lupine. A 1990 survey by Indiana DNR searched 24 sites with potential Karner habitat; six were found to be inhabited by the Karner blue butterfly and are within Indiana Dunes NL.

* * *

Two NPS scientists, Walter Loope of Pictured Rocks and Lisa Thomas of Wilson's Creek, were visiting lecturers at U/WI, Madison, courtesy of the Great Lakes CPSU. Loope visited the Geography and Geology and Geophysics and lectured on fire ecology in northern hardwoods. Thomas visited in the Dept. of Landscape Architecture and presented a seminar on prairie restoration.

Whale Stranding at Everglades NP

On the afternoon of Jan. 30, 1992, an Everglades NP visitor reported a group of whales, later identified as short-finned pilot whales (*Globicephala macrorhyncha*) attempting to strand on the remote wilderness beach of Northwest Cape. Regional, state, and local marine mammal stranding authorities were contacted for advice.

Due to the remoteness of the area, limited care facilities and a poor rehabilitation record for the species, a rescue and removal effort was not undertaken. Park Rangers responded to find 11 pilot whales stranded with one dead and three more swimming slowly offshore. The rangers attempted to refloat the whales and after a short time all were moving about in deeper water offshore. Efforts to save stranding pilot whales often prove futile because the animals restrand immediately at the same location or some time later several hundred kilometers away.

The following morning park staff conducted boat and aerial surveys of adjacent coastline, but no pilot whales were observed. Later that morning, biologists from the Florida DNR and the National Marine Fisheries Service were delivered to the site by Florida Marine Patrol helicopter to conduct a field necropsy. The animal was a 332 cm female with congested lungs and stomach ulcers. Cause of death was bacterial pneumonia.

Park staff later learned that on the morning of January 30, local fishermen had observed as many as 26 whales attempting to strand at the same location, with an undetermined number swimming in the surf around their boats. The fishermen had attempted to refloat the whales while trying to radio for assistance. Approximately a week later, three pilot whales were found stranded, two dead and one alive, south of Naples, FL, well to the north of Northwest Cape.

Pilot whale strandings, often involving 100 or more animals, are common in North America, for reasons still not known. The largest recorded U.S. stranding occurred in 1933 and involved over 200 pilot whales in what is now Everglades NP, from East Cape Sable to near Flamingo. The recent event has park staff talking with marine biologists and reviewing just what kind of intervention is appropriate for a national park.

Air Quality Division

Kathy Tonnessen, Director of the NPS Air Quality Division's Biological Effects Program, was co-author with Mark Williams (U/CO) of a paper on "Hydrologic and Hydrochemical Lessons for the Front Range: An Overview of the Emerald Lake Watershed Study," presented at the Front Range American Geophysical Union meeting in February. The authors discussed results of an intensive watershed investigation at a high elevation watershed in Sequoia NP, with emphasis on the importance of studying snowfall and snowmelt to assess the potential for lake and stream acidification. This work is being continued under NASA sponsorship as part of the Earth Observing System (EOS), and will include monitoring of high elevation sites in the Sierra Nevada, the Rockies, and mountain sites in China and Austria.

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The Division recently published the proceedings of a workshop co-sponsored with the Water Resources Division on Acid Rain and Air Pollution in Desert Park Areas, by D. Mangis, J. Baron, and K. Stolte (Tech. Rpt NPS/NRAQD/NRTR-91/02). The volume includes 12 papers presented at the conference that address the nature of air pollution and deposition in the West and the potential for damage to aquatic and terrestrial ecosystems and cultural resources. Copies may be had from the Tech. Info. Center in Denver, (303) 969-2130. The Division is involved in a review of air pollution issues in Saguaro NM. Tonnie Maniero (Policy, Planning, and Permit Review Branch) is organizing the review of the biological effects research program sponsored by the AQD since 1984. The review will evaluate the levels of ambient air pollutants and deposition in the monument and potential impacts on vegetation.

* * *

Deborah Mangis, biologist with the Research Branch, attended a global change and air pollution research coordination meeting organized by the USFS, Southern Global Change Program, Raleigh, NC. Representatives from federal agencies, industry groups, and universities presented information on ecosystem studies in the southern U.S., emphasizing potential impacts of oxidants, acid deposition, air toxics, and global change on forest ecosystems. Attendees discusssed sharing of research sites and funding – discussions that were continued at the Forum on Air Quality Management in the Southern Appalachians in March at Gatlinburg, TN.

Southwest Region

Dr. Samuel Kunkle, formerly with the USFS in Washington, DC, has accepted the post of Regional Chief Scientist, relieving Dr. Milford Fletcher, former chief scientist, to lead the new CPSU at U/NM, Albuquerque. Prior to his USFS assignment, Kunkle for five years worked for NPS in the Fort Collins-based Water Resources Division. His field is tropical forestry.

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Robert Krumenaker, formerly a resource management specialist at Isle Royale, is now a physical scientist in the Southwest Region, replacing Keith Yarborough who, in turn, has become the first park scientist to be stationed at Big Bend NP. Yarborough also maintains offices (two days a week) at Sul Ross University in nearby Alpine, TX.

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Jerry McCrae, formerly NPS-IPM coordinator in Washington, DC, is now leader of IPM in the Region, replacing Gerry Hoddenbach, who is on temporary leave to be with his wife, Lois, who is the new safety officer at Grand Canyon NP.

Rocky Mountain Region

In October 1991, a wild horse roundup, conducted in Theodore Roosevelt NP with 2 helicopters and 12 riders, captured 93 of the park's 114 wild horses. Of these, 58 wer sold at auction, the remainder were released into the park as part of a historic demonstration herd. Blood was taken from 77 animals for genetic testing at U/KY. This reduction, the first since 1986, received wide publicity due to claims that park horses are a distinct breed, descended from Sitting Bull's ponies (a premise disputed by area ranchers).

Last year, a bill to make this so called "Nokata Horse" the state horse failed in the ND legislature. Attempts to halt the roundup through the state's Congressional delegation and governor's office were unsuccessful. Representatives from the Human Societies of both the U.S. and ND were pressent. The culling eliminated animals introduced in recent years with the goal of preserving traditional bloodlines. Genetic analysis combined with recent range use and carrying capacity studies of the park herd will establish a minimum herd size.

* * *

Devils Tower NM completed an extensive exotic plant mapping project in 1991. The Braun-Blanquet species abundance mapping method was used to map 53 of the 55 exotic species known from the Monument. Results will be used as a baseline to monitor changes in distribution and abundance of exotic plant species over time, to evaluate effectiveness of control methods, and to determine the best locations to concentrate control actions.

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Last fall, Mesa Verde NP experimented with a magnetometer to locate faults, dikes, and remnants of large archeological surface sites. The magnetometer was

Continued on page 22

made available through the USGS for two months of field work by Dr. Mary Griffiths. The device detects local differences in the earth's magnetic field, brought about by the presence of iron rich minerals in intrusions, iron in solution, or iron in rocks (as in the base of archeological sites). In Mesa Verde, faults and dikes are related to localized unusual vegetation types, water outcrops, and interesting terrain features.

* * *

Because of the difficulty of funding small-scale, high priority, hands-on natural resource management projects from park base (especially for medium and small size parks), a regional program called PRAM (for Preservation, Restoration, and Mitigation) was started in FY 91. Of 74 proposals submitted for FY 91 funding, 23 projects ranging from $1,200 to $10,000, received a total of about $150,000.

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Responsibilities for the region-wide competitive research program is being shifted from U/WY to the Regional Office, at least until pending recommendations of the National Academy of Sciences are circulated and incorporated into the NPS science program. After almost 15 years of productive cooperative agreement with U/WY, it was concluded that the NAS recommendations might alter significantly the scope of the NPS competitive research program. Thus, any decision to advertise and award a cooperative agreement for future assistance will be delayed until the NPS response to the NAS recommendations is developed.

North Atlantic Region

John T. Tanacredi, Research Scientist and Chief of Resource Management and Compliance at Gateway NP in NYC, was a keynote speaker at a recent Colloquium on Urban Marine and Coastal Issues held at Kingsborough Community College's new Marine and Academic Center. Tanacredi's address, "Issues at the Edge," dealt with the problems of our fragile coastlines and the need for further research and information sharing.

But "more important than merely making information about coastal problems more widely known," he said, "we must cause deliberate change in human activities along our coastline, shores and estuaries ... we must apply basic research to their day-to-day operational needs." He called for a companion to Aldo Leopold's land ethic concept – a "sea ethic" which, among other things, would allow natural systems to heal themselves by limiting human-caused disturbances and cultivating an ecological conscience in our dealings with the sea.

Western Region

From the CPSU at U/AZ comes news of an article by P.S. Bennett and M.R. Kunzmann, "The Applicability of Generalized Fire Prescriptions to Burning of Madrean Evergreen Forest and Woodland" in the ***Arizona-Nevada Academy of Science Journal*** (24-25:79-84); and two technical reports:

Ruffner, G.A. and R.A. Johnson. 1991. Plant ecology and vegetation mapping at Coronado National Memorial, Cochise County, AZ, 75 p. Tech. Report #41, and

Bellantoni, E.S. and P.R. Krausman. 1991. Habitat use by desert mule deer and collared peccary in an urban environment, 39 p. Tech. Report #42.

Copies of these and a complete listing of the CPSU publications are available by calling (602) 670-6886.

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Mary Ann Madej, Redwood NP geologist, has completed a 160-page report, "Analysis of Bank Erosion on the Merced River, Yosemite Valley, Yosemite NP." The work was in response to the perceived threat of severe bank erosion in the Valley. She and coauthors William Weaver and Danny Hagans measured channel widths, compared them to those surveyed by USGS in 1919, and found that not only bank erosion but net channel widening had occurred in the most severely impacted stream reaches. Channel width increases, up to double the 1919 values, were most extreme in areas with intensive levels of visitor use.

They evaluated possible causes of channel widening, including hydrologic, climatologic, and physical factors, and concluded that human trampling, destruction of riparian vegetation, and flow constriction at bridge sites were primary causes of bank erosion. Riparian restoration techniques, including aggressive revegetation efforts, biotechnical controls, and removal or modification of harmful structures, were recommended to park management.

* * *

Redwood NP women on the Research and Resource Management staff were featured in an article by Vicki Ozaki in ***Women in natural resources.*** The special issue (Vol. 13, #1), dealt with women involved with natural and cultural work for NPS.

* * *

Nathan L. Stephenson (Ph.D. Cornell, 1988) has been hired as a Research Ecologist at Sequoia and Kings Canyon NPs, on funds provided by the Global Change Program. He will serve as a PI on studies of forest demography and the environmental controls on species distributions and ecosystem processes. His 1990 paper, "Climatic control of vegetation distribution: the role of the water balance" published in the ***American Naturalist*** (135:649-670), already has become something of a classic.

* * *

Recent publications from NPS Western Region scientists are:

• Stephenson, Nathan L., David J. Parsons and Thomas W. Swetnam. 1991. Restoring natural fire to the sequoia-mixed conifer forest: should intense fire play a role? This paper for the first time surfaces the idea that locally intense fires may have been important in the creation of conditions necessary for establishment of the characteristic groupings of apparently even aged giant sequoia that visitors find of such interest. The possibility has significant implications for future prescribed fire management.

• Parsons, David J. 1991. Planning for climate change in national parks and other natural areas. ***The Northwest Environmental Journal*** 7:255-269. Presents an overview of issues related to climate change of special interest to national parks. It highlights early progress made by the NPS Global Change Program.

• Parsons, David J. 1991. Preparing the Sierran parks for global issues of the 21st Century. pp. 150-155 in ***Yosemite Centennial Symposium Proceedings***. Yosemite Assn., El Portal, CA. This paper reflects the multitude of threats facing the Sierra Nevada parks in the coming years and is particularly relevant to the new approach to bioregional planning reflected in the Sierra global change research program.

* * *

The NPS was highlighted in a special 2-day symposium Feb. 7-8, 1991 at the AAAS annual meetings in Chicago. The symposium, Efficacy of Long-Term Research in U.S. National Parks, was organized by Gary Davis and Bill Halvorson of Channel Islands NP as a product of an I&M initiative to present a series of case studies on the subject. When AAAS heard about the project, they asked to feature it at their national meeting and are planning to publish the 12 papers in book format.

Arthropod Populations At 3 Golden Gate Habitats Compared

French broom, an exotic shrub, has invaded native coastal scrub and grassland communities of the Golden Gate National Recreation Area (GGNRA). This plant is aggressive and very successful, forming dense, monospecific stands, which threaten the park's natural plant diversity. A field study was conducted to compare the arthropod fauna (insects and arachnids) in three different plant communities within GGNRA: coastal scrub, gassland, and French broom.

Arthropods were sampled in pitfall traps over a period of four days in mid-July 1991, during which 16,374 arthropods were collected from 36 traps. The dominant organism in both scrub and grassland habitats was the exotic Argentine ant. Only three other species of ants were collected. It is possible that the Argentine ant has displaced the native ant fauna and thereby indirectly threatens the endangered Mission Blue butterfly, which has a symbiotic relationship with some native ant species. This situation warrants further study.

The diversity of native arthropods (calculated using the Shannon-Weiner index) was highest in scrub, followed by grassland, and finally broom. In fact, it was shown that the invasion of French broom into native plant communities decreases the diversity of native arthropods by 1/3. Most species of arthropods found in broom also are found in either scrub or grassland in substantial numbers, so removal of broom does not threaten their populations. However, other species, such as spiders, beetles, and wasps, may be directly threatened by the spread of French broom.

Areas within the park that have been invaded by French broom are undergoing restoration by removal of broom and revegetation with native species. The results of this study will provide park resource managers with baseline data that previously were unavailable and will contribute to restoration and management of native communities.

Jot Lanford and Laura Nelson
Natural Resources
GGNRA, Fort Mason, Bldg. 201
San Francisco, CA 94123

gis notes

The second Servicewide GIS Users" Conference (GIS91) was held Nov. 18-22 in Lakewood, Colo., bringing together for the first time in three years all NPS users of GIS, CAD, and automated mapping technologies. Attending were 194 Service people, representing 120 NPS units and all 10 Regions.

Jan van Wagtendonk of Yosemite NP opened the conference with a perceptive perspective on 20 years of GIS in the NPS. A poster session gave participants a chance to present their respective applications, illustrated by 54 posters from 44 NPS units. Posters included analysis of endangered species habitat, siting of park housing, use of global positioning systems, management of exotic species, monitoring of endangered species, analysis of Civil War battlegrounds, management of grazing, tracking of mining, analysis of aircraft-overflight noise, and analysis of visitation statistics, among many others.

Attendees voted Joshua Tree's poster on tortoise monitoring as Most Innovative; Yosemite won Best Looking; Colonial, Most Multi-disciplinary; and Colonial, Santa Monica Mountains, and Yosemite finished in a three-way tie for Best Use in Decision-making.

Plenary sessions featured presentations from the Information and Telecommunications and Geographic Information Systems Divisions, the Regional GIS coordinators, and 12 NPS program offices. Topics included Servicewide ADP standards; the status of hardware, software, and data in the Servicewide GIS program; GIS training; telecommunications; data issues (collection, standards, management, quality); the reorientation of the GIS Division; the status and direction of the Regional GIS programs; the current and intended use of GIS technology and sharing of GIS data by NPS program offices, and funding and staffing of GIS projects throughout the Service.

Ten technical workshops focused on Global Positioning Systems, Data Sources, Cave GIS, Position Description and Classification, Map Preparation, Electric Power, Hardware, Text Data in GRASS, Future Directions in GRASS, and Networking.

The conference provided a welcome and useful opportunity for GIS users from around the Service to share experiences and ideas, to hear about institutional and programmatic directions for the Servicewide program, and to learn about technical issues. In the three years since the last such gathering (at Luray, Va., 1988), the interest in, and use of, GIS technology has grown enormously and attendees voiced a common feeling that the conference was a valuable and timely event.

GIS93 has been set for Nov. 15-19, 1993, in Denver. See y'all there.

* * *

In a rare conjunction of events, the International Society for Photogrammetry and Remote Sensing (ISPRS), the American Society for Photogrammetry and Remote Sensing (ASPRS), the American Congress on Surveying and Mapping (ADSM), and Resource Technology 92 (RT92) will hold a joint congress and convention in Washington, DC, Aug. 3-7, marking the first time in 40 years that the ISPRS will meet in the United States.

Theme of the Congress is "Mapping and Monitoring Global Change," and between 7000 and 9000 surveyers, technicians, photogrammetrists, remote sensing and GIS specialists, educators, scientists, and engineers from more than 80 countries are expected to attend, hear, and present papers in some 30 topic areas.

For more information contact me at 303-969-2593, FTS 327-2593, or FAX 303-969-2822, or Alan Voss, TVA (615-751-5425).

Harvey Fleet, Chief
Digital Cartography
NPS GIS Division, Denver

Sierra Summit Conference Takes Region's Pulse

The environmental woes of the Sierra Nevada were laid out like entrails for the uncensored inspection of 200 scientists and natural resource managers last November at Lake Tahoe. The "physical exam," organized by California Secretary of Resources Doug Wheeler, marked the first time in history that a panel of experts convened to discuss the health of the entire mountain range – all 430 miles and 15.5 million acres. The prognosis was a solemn question mark. The exercise touched sensitive nerve endings up and down the entire spectrum of "multiple users."

A firsthand account from Dave Parsons, NPS Research Scientist at Sequoia and Kings Canyon NPs, (a Natural Environment panelist on opening day of the 3-day conference), and supplemented by accounts in the ***Sacramento Bee***, concluded that the patient is sick, its vital signs – soil, water, air, forests, and wildlife – assailed by a formidable array of threats. Ozone pollution and acid rain, mercury contamination, harmful logging and grazing practices, overdevelopment, and bureaucratic and scientific neglect were identified by the conferees as major players.

Panel findings:

- Soil is eroding from parts of the Sierra at catastrophic rates, filling water reservoirs with mud and silt. Road building, livestock grazing, logging – all contribute to the problem.
- 24-hour average ozone levels in summer at Sequoia NP exceed those in Los Angeles – home of the worst air in America.
- 8 of the Sierra's 22 amphibian species are threatened with extinction; populations of many other creatures, including songbirds, are declining.
- Fire suppression, logging, and air pollution are changing the very fabric of the Sierra forest – long regarded as one of the world's grandest assemblages of trees.

Dave Graber, Sequoia NP Research Biologist, described the threats to wildlife resulting from damage to wetland systems, emphasizing the need for more knowledge about wildlife, without which "we won't have information to manage – we won't even know when we lose them."

Parsons listed major management issues – fire suppression, timber harvest (revegetation and old-growth), grazing, air pollution, drought/pests, urban and residential sprawl, plant species and community issues, genetic and biological diversity, and future global climate change – all areas of great concern for land use management planning.

Secretary Wheeler opened the summit with a strong pitch for a coordinated, bioregional approach to conservation of the Sierran forests, lakes, rivers and wildlife. Most conferees seemed willing to follow his lead.

The region's chief federal forester, Ronald Stewart, told conferees that management of the Sierra's 20 million acres of federal forest no longer will be driven by timber targets or volumes of wood from trees sold to loggers. He predicted that wildlife and recreation interests will edge out logging as the chief objectives on California's national forests. Logging, he indicated, will be allowed where it enhances recreation or wildlife.

As ***Sacramento Bee*** reporter Tom Knudson put it, "Not since naturalist John Muir preached his mountain gospel a century ago has the Sierra Nevada seen such an outpouring of interest, concern and controversy." The crowd of "movers and shakers from all walks of mountain life: national park superintendents, university scientists, state policy-makers, timber company officials, conservationists," saw hope in the snowstorm of information, the avalanche of reports, and the willingness of those present to listen and make note of one another's viewpoints and agendas.

Global Change Update

The Service's Global Change Research Program has approved 14 new research projects in 8 biogeographic areas to complement the 14 projects commenced in FY 1991. 4 new biogeographic areas (Central Grasslands, Gulf Coast, Sonoran Desert, and South Florida) and a new thematic initiative (coral reefs) join the 6 areas with ongoing work (Colorado Rockies, Glacier NP Area, Olympic Peninsula, Ozark Highlands, Southern and Central Sierra Nevada, and Western Great Lakes) to enhance the list of areas with approved proposals.

Specific projects slated to begin this year include research on holocene paleoenvironments in Western Great Lakes parks, effects of global change on Colorado Rockies vegetation, projecting climate and vegetation change for the Central Grasslands, and dynamics of the Southwest Florida mangrove/marsh fringe belt.

The Global Change Research Program has progressed greatly toward its goal of being a complete, well-integrated program. The newly approved projects fill many geographical and topical gaps in the initiative. As program funding increases, we will commence research in more of the 20 included biogeographic areas, further increasing our understanding of global change, and enhancing our ability to generate results useful for resource management.

The program's new booklet, "Global Change Research in U.S. National Parks," provides an overview of the Service's program, as well as thumbnail sketches of the areas in which we're currently pursuing, or planning to pursue, research. To obtain a copy, contact Dr. Peter L. Comanor, Global Change Program Coordinator, WASO Wildlife and Vegetation Division, P.O. Box 37127, Washington, DC 20013-7127.

For more than a decade, researchers have considered the last major change in the Earth's magnetic field to have occurred 730,000 years ago – between the Brunhes and Matuyama geomagnetic periods. But recent experiments by Geophysicist Michael McWilliams of Stanford University, using the argon-argon technique, suggest that this transition occurred 50,000 years earlier ... causing changes in the rock-dating results reached on the basis of the 730,000 year yardstick. McWilliams used the argon-argon technique, a variation of the standard potassium-argon dating method, to arrive at the 780,000-year figure as the interval between the Brunhes-Matuyama transition and the present. His finding confirms results reported last year by oceanographers who redated the transition by counting the number of Earth's orbital oscillations in ocean sediments. ***Science News*** reports (Vol. 141, p. 14) that redating the Brunhes-Matuyama transition eliminates some of the problems faced by scientists studying the San Andreas fault. The new yardstick eliminates discrepancies between their precise measurements across the fault that suggest the Pacific plate moves past North America at a rate of 48mm per year and the 51mm-per-year speed arrived at by way of estimates based on magnetic lineations in the ocean.

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Mt. Pinatubo's volcanic cloud seems to be playing havoc with the ozone over Boulder, Colo., according to ***Science News*** (Vol. 141, p. 14). The day a patch of Mt. Pinatubo's cloud passed overhead, balloon flights over Boulder measured the lowest December ozone values ever recorded at this site. David Hofmann of NASA in Boulder, said the low reading may in part reflect ozone destruction catalyzed by sulfuric acid particles in the cloud, and he predicts that when the cloud travels to the far south it may generate an "extra" ozone hole during the Antarctic fall. (The "usual" ozone hole appears during Antarctica's spring.)

⁂

A new research effort – the Task Force on Declining Amphibian Populations – has been established at Oregon State University in Corvallis, supported by the IUCN in collaboration with OSU's Center for Analysis of Environmental Change. James Vial, coordinator of the task force, says researchers around the world will document the extent of amphibian die-offs and study anything that might be causing it.

In Oregon's Cascade range, scientists have documented the unexplained die-off of millions of toad eggs in alpine lakes; the once common western spotted frog has become extinct in Western Oregon; in the Rocky Mountains, boreal toads that once clogged hiking trails are now scarce.

According to Professor Vial, the die-offs may be an early indicator of something seriously wrong in the global environment that later will affect a range of plant and animal life. "It's important," he said, "to determine whether it's a natural phenomenon or an indicator of some other environmental impact." Major research efforts underway include an $800,000 3-year study in Costa Rica and the $272,000 study at OSU.

⁂

"National Parks Fire Policy: Goals, Perceptions and Reality" is the title of a conference sponsored by Renewable Natural Resources Foundation and hosted by Utah State University's College of Natural Resources last Nov. 15-16 at Snowbird, Utah. Participants included NPS Associate Director for Natural Resources Eugene Hester, NPS Research Scientists David J. Parsons and Jan van Wagtendonk, Yellowstone NP Chief of Research John Varley, and former NPS Fire Ecologist James Agee. Parsons moderated Session I: Goals of the National Parks – a discussion of the need for increasing specificity of natural resource goals for NPs, and of the real and perceived conflicts involved in managing national parks – between scenic values and ecological goals, in maintaining natural values in light of increasing visitation, and when policy only partially allows natural processes to play a role.

⁂

Given the long, checkered history of the search for sun-climate relations, many researchers will call it a statistical freak, but the "dazzling correlation" between solar activity and terrestrial temperature presented in the Nov. 1, 1991 issue of ***Science*** is "giving climatologists goose bumps." So says Richard Kerr in the magazines Research News section, commenting on the findings presented on pages 698-700 by Eigil Friis-Christensen and Knud Lassen of the Danish Meteorological Institute. The graphic representation shows two curves, tightly intertwined: one representing the interval between peaks in sunspot abundance, the other tracing the annual rises and falls of earth's average temperature.

Among the oft-fooled and thus wary body of climatologists, John Eddy of Boulder, Colo., and David Parker of England's Hadley Center for Climate Prediction and Research voiced a host of reservations, but admitted they were "mightily impressed" by the correlation coefficient of 0.95 – probably the highest ever found in this sort of work. The authors themselves suggest merely that variations in the solar cycle length appear to be "a possible indicator of long-term changes in the total energy output of the sun," and add:

"Estimation of the natural variability of the Earth's climate and its causes are needed before any firm conclusion regarding anthropogenic changes be made."

⁂

The potential magnitude of future vegetation change in Eastern North America is described by a paleontologist, a geographer and a geologist in ***Science*** Vol. 254:692-695 and their predictions could spell a vegetative nightmare for natural resource managers.

J.T. Overpeck, P.J. Bartlein, and T. Webb III provide a model-based assessment of how the natural vegetation of Eastern North America may change over the next 2 to 5 centuries in reponse to trace gas-induced climate change. They used pollen data and response surfaces to model the equilibrium response of vegetaton to the climate change simulated by atmospheric general circulation models (GCMs) and found that increases in atmospheric trace gas concentrations could warm the global average temperature 1.5 degrees to 4.5 degrees Centigrade by the end of the next century. Application of climate-pollen response surfaces to 3 climate model simulations of doubled preindustrial atmospheric CO_2 levels shows the change in the equilibrium distribution of natural vegetation over the next 200 to 500 years could be larger than the overall change during the past 7,000 to 10,000 yours and equivalent to the change that took place over the 1,000- to 3,000-year period of most rapid deglaciation. Some plant ranges and abundance maxima could shift as much as 500 to 1000 km in the next 200 to 500 years.

⁂

The Florida DNR Newsletter, ***Resource Management Notes***, January 1992, contains (pp. 16-17) an item about Ant Surveys in Florida's State Parks, by Dr. Mark Deyrup of the Archbold Biological Station (813) 465-2571, excerpts from which are herewith reproduced.

"It is no news to Florida naturalists that the state is richly, even extravagantly, endowed with ants. With about 180 species, Florida is the ant capitol of the country ... Such a significant group deserves its own guidebook, and for the last 8 years I have been looking at ants throughout the state in preparation for a book on identification and natural history of Florida ants ...

"My last printout of state park ants, about a year old, contains about 500 entries from 30 state parks. Unfortunately, lists of ant species are not very informative to most people and I am trying to devise a system that will allow me to print up lists of species with a little information blurb on each species ... information on whether the species is native, its origin if exotic, its size, nest site, habitat, and any interactions with humans (normal humans, not ant people).

"A survey that shows that ants abound in Florida's state parks might appear to have been commissioned by the Florida Calamity Calendar or by some obscure religious sect that believes picnicking to be a sin. Even I find it difficult to imagine how an impressively long ant list for a particular park could be used in any positive publicity. The list could be accompanied by a statement that most of these ants are tiny, secretive, benign creatures that will never be seen by park visitors, but even this statement resembles damage control more than it does positive publicity.

"Eventually, of course, the public will come to the enlightened view that arthropod diversity is one of the most spectacular and fascinating features of the natural world. Pending that happy day, one may want to use the information with some caution. For example, one could lump the 68 ant species known from a park with the 19 butterfly species, and say 'There are 87 species of butterflies and other insects known from this park.' ... Perhaps Florida state parks have a role to play in ushering in the Age of Ant Appreciation."

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Perhaps even more distressing as environmental news than the decline of amphibians on the world scene is the catastrophic decline of mushroom populations throughout Europe. "Mass extinction" is the term used by John Jaenike, University of Rochester ecologist, who is concerned that fungi also may be vanishing from the United States.

The findings (or rather, the no-longer-findings) of Eef Arnolds – a fungal ecologist at the Agricultural University of the Netherlands, are described by Jeremy Cherfas on page 1458 of the Dec. 6, 1991 issue of ***Science***. The scale of loss is shown by comparing surveys carried out in the Netherlands between 1912 and 1954, when an average of 71 species of fungus was found per foray, with the period between 1973 and 1982, when a matched series of 15 surveys could turn up only 38 species per foray.

Both occurrence and size of mushrooms have plummeted. It took 50 times as many chanterelles to make up a kilogram in 1975 as it did in 1958. Arnolds rules out overpicking and forest management prac-

information crossfile

tices, because both edible and inedible mushrooms have declined and all types of mature forests show similar drops. The villain appears to be air pollution. Throughout Europe there is a negative correlation between abundance and diversity of fungi and levels of nitrogen, sulfur, and ozone in the air. The main offender appears to be farming.

The loss of a gourmet item of human food is not nearly so consequential as the loss of the network of fungal filaments that live in close symbiotic association with trees, providing water and minerals in exchange for carbohydrates. The resulting lowered resistance of trees to stress could lead to a mass dying of trees in time of severe frost or drought, Arnolds warns.

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From Wildlife Ecologist Doug Houston, at Olympic NP, comes an article by Paul Beier in the ***Wildlife Society Bulletin*** (19:403-412, 1991), titled "Cougar Attacks on Humans in the United States and Canada." The author attempted to document all attacks from Jan. 1, 1890 through Dec. 31, 1990 and describes his very conservative criteria for deciding whether the verified reports constituted "attacks" or "near-attacks." He documented 9 fatal attacks and 44 nonfatal attacks resulting in 10 human deaths and 48 nonfatal injuries. (The greater number of victims occurred because there were 2 victims in each of 5 attacks.) He deduced that cougar attacks "have clearly increased during the last 2 decades" and describes the victims (37 of 58 victims were children), their companions (or lack of), their positioning with regard to human habitation, and general deportment.

He describes behaviors that invite attack, behaviors that might prevent attack, and concludes that yearlings and underweight cougars are most likely to attack humans. Aggressive responses on the part of intended victims may avert an impending attack and repel attacks in progress, he found.

Houston notes that the article is "a good and timely summary" and adds that "we seem to be experiencing an increase in 'near-attacks' here at Olympic, but sample size is very small (thankfully)."

⁂

An article titled "Plight of the Plover" by Kathy Fackelmann, in the Dec. 7, 1991 issue of ***Science News***, describes the continuing stress under which the piping plovers (now on the threatened species list) must conduct their foraging and nesting practices. Both sanderlings and plovers are increasingly restricted in their foraging attempts by having to flee from humans – thus cutting their food intake. These birds cannot transfer their feeding to salt marshes or mud flats as many other shorebirds have done under human pressure. They have no alternative but to continue their efforts to feed in the same waves as recreational bathers and try to escape the plover predators who are attracted to plover habitat by human garbage left on the beaches. Fackelmann concludes the average citizen can have a big impact. "People can help protect the birds from predators by keeping beaches clean and pets leashed. And joggers, for their part, can maintain a respectful distance from these highly flappable foragers."

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The Dec. 6, 1991 ***Science*** "News and Comments" section carries a discussion of the worldwide impact of invasive exotic species, written by Elizabeth Culotta. The article is built around the October 1991 gathering sponsored by the Indiana Academy of Sciences to discuss "the homogenization of the world" and the biological threats thus imposed. The article describes the havoc wrought in manyh places in terms of lost crops and expensive control programs, and then discusses the "less visible ecological damage on a grand scale" that such invaders can inflict.

"When ecosystems are already under stress, as they now are in most parts of the world, a biological invader can deliver the coup de grace to native species by predation, competition, or by transforming landscapes," Culotta notes.

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A special issue of Water Resources Research on Western U.S. Alpine Watershed Studies (WRR 27:1537-1588, July 1991) contains 5 papers that discuss the Emerald Lake Watershed Study, an intensive site investigation of the biogeochemistry of a headwater system at 2800 m in Sequoia NP. Kathy Tonnessen of the Air Quality Division in Denver provides the introduction and discusses the cooperative program between NPS and the California Air Resources Board to determine impacts of acid deposition on watersheds and surface water quality. This study, conducted from 1983-1989, demonstrated the importance of snow chemistry and snow melt processes to the episodic acidification of dilute lakes and streams in the Sierra Nevada.

⁂

William Smith, Yale University, presents an excellent review of "Air Pollution and Forest Damage" in ***Chemical and Engineering News*** (69:30-43, Nov. 11, 1991). He recaps conclusions of the NAPA Program's conclusions regarding impacts of ozone and acid deposition on terrestrial ecosystems and then ranks regional air pollution stresses to vegetation as: ozone, heavy metals, and acid deposition. He stresses that the future of this research lies with long-term programs that document the health of forests and that attempt to distinguish negative effects of air pollution when compared to other natural (pests, disease) and anthropogenic stresses.

Fossil Butte To Host Paleontological Meeting

Fossil Butte National Monument will celebrate its 20th anniversary by hosting a 4-day Paleontological Resources Conference in September 1992 (specific dates to be determined). The conference will be directed toward managers, resource specialists, and interpreters, but will involve researchers as well. Paleontological resources are a relatively new issue within the NPS and periodic conferences have proven valuable to park managers and interpreters. BLM, USFS, and several Western state park managers also will be invited.

Major topics will cover development and encouragement of paleontological research on federal lands, interagency cooperative agreements, care and maintenance of paleontological collections, creative alternatives to interpreting fossil resources, recent developments in legislation dealing with such resources on federal lands, state permit systems, pertinent law enforcement issues, the challenge of exhibiting fossils in situ, and unique paleontological management programs at selected state parks.

If you have suggestions at this planning stage, the conference committee would like to hear from you. Questions, suggestions, and requests to be on our mailing list should go to Rachel Benton at Fossil Butte (307) 877-4455.

meetings of interest

1992

Apr. 23-24, MAPPING TOMORROW'S RESOURCES, A Symposium on the Uses of Remote Sensing Geographic Information Systems and Global Positioning Systems for Natural Resource Management, Utah State Univ., Logan, Utah. Contact: Dean's Office, Coll. of Nat. Res., Utah St. Univ., Logan, UT 84322-5200 (801) 750-2445.

May 4-6, THREATS TO THE NATIONAL WILDERNESS PRESERVATION SYSTEM: THE MANAGERIAL CHALLENGE, in Portland, OR; sponsored by NPS, USFS, BLM, and the Society of American Foresters Wilderness Subcommittee. Keynote speaker, Rupert Cutler; banquet speaker, Cong. Vento (D-MN). Contact: Alan Schmierer, NPS Western Regional Office, 600 Harrison St., Ste. 600, San Francisco, CA 94107; (415) 744-3959.

May 15-17, CRATER LAKE NP 90TH ANNIVERSARY SYMPOSIUM, Southern Oregon State Coll., Ashland, OR. Contact: Dr. Frank Lang, Dept. of Biology, Southern OR/State/Coll, Ashland, OR 97520 (503) 552-6342.

May 17-20, FOURTH NORTH AMERICAN SYMPOSIUM ON SOCIETY AND RESOURCE MANAGEMENT, in Madison, WI; more than 250 papers focusing on social biological aspects of natural resource and environmental issues, 4 plenary addresses, round tables, poster session, and field trips. Contact: Mary Miron, School of Nat Res, 1450 Linden Dr., Rm. 146, U/WI, Madison 53706; (608) 262-6968.

June 22-25, BIODIVERSITY TRAINING COURSE, location to be announced. See Mar. 9-12 notice above.

Aug. 3-7, MAPPING AND MONITORING GLOBAL CHANGE, is the theme of a 4-way Congress and Convention in Washington, DC., involving the Int'l Soc for Photogrammetry and Remote Sensing, the Amer. Soc. for Photogrammetry and Remote Sensing, the Amer. Cong. on Surveying and Mapping, and Resource Technology 92 (See GIS Notes, this issue, page 23).

Oct. 27-30, 19TH ANNUAL NATURAL AREAS CONFERENCE and 14TH ANNUAL MEETING OF THE NATURAL AREAS ASSN, at U/IN campus, Bloomington. Contact: Division of Nature Preserves, U/IN, 402 W. Washington St., Rm. W 267, Indianapolis 46204; (317) 232-4052.

Nov. 16-20, PARTNERS IN STEWARDSHIP, the George Wright Society Conference on Research and Resource Management in Natural and Cultural Parks and Reserves, Jacksonville, FL. Contacts: John Donahue, NPS, 18th & C Sts NW, Washington, DC 20240 (202) 208-4274 and Harry Butowsky, NPS, PO Box 37127, DC 20013-7127 (202) 343-8155.

Archeological Fieldwork At Yellowstone's Obsidian Cliff

By Leslie Davis, Stephen Aaberg, and Ann Johnson

Obsidian Cliff is only one of a number of potentially glassy rhyolite flows in and around Yellowstone NP, however prehistoric people selected that high quality obsidian source for tool making more often than any other Rocky Mountain source. Based on the chemical "fingerprinting" of archeological obsidian (primarily from sites outside the park), it is now known that early Native Americans were selecting and using Obsidian Cliff obsidian for making tools by at least 11,000 years ago. Intermittent use of obsidian quarried from Obsidian Cliff continued into the early historic period.

Obsidian Cliff is the name given one of four rhyolite lava flows north of the Yellowstone caldera. This topographic feature within the Rhyolite Plateau was formed 180,000 years ago by eruption through a vent 1 km to the east of where the highway between Norris and Mammoth passes Obsidian Cliff. That flow filled a preexisting valley and rapidly chilled against the old valley wall. Obsidian Creek downcut through the old valley wall and exposed the obsidian cliff. The top of the flow is covered by a loose rubble mantle resulting mostly from frost weathering of local bedrock. The presence of Paleozoic quartzite, Quaternary basalt, and igneous erratics suggests deposition by glacial transport and ice decay.

The NPS contracted with Montana State University in 1988 for technical data needed to develop a National Historic Landmark nomination for Obsidian Cliff. An archeological study was initiated because little was known regarding the spatial extent of quarry features, prehistoric obsidian procurement practices, and the within-source trace-element composition and geochemical variability of Obsidian Cliff obsidian.

Work was designed to provide evidence essential for understanding prehistoric quarrying activity and to analyze obsidian samples in order to fingerprint geochemically the Obsidian Cliff flow. Before fieldwork could begin, however, the Obsidian Cliff flow area was burned by the Wolf Creek fire of 1988. The survey was postponed and conducted during the 1989 field season. The burnoff of heavy vegetation cover created an additional research opportunity: to assess fire effects on prehistoric cultural features, artifacts, and geological obsidian.

As with most of the 1988 fires in Yellowstone NP, the Wolf Creek fire burned with varying intensity, differentially affecting specific geological and cultural landscapes. This mosaic burn pattern was evident over much of the Obsidian Cliff flow, approximately two-thirds of which was intensely burned.

The 1989 archeological study recorded 59 prehistoric obsidian procurement loci (discrete small-scale activity areas) within the exploited Obsidian Cliff flow. The plateau is considered to be a single, extensive lithic procurement site (48YE433). Surface and subsurface obsidian procurement loci (quarry features) are the most prominent archeological manifestations on the plateau. The quarry features vary in form and scale, ranging from single oval pits to multiple overlapping/interlocking pits that occupy large surface areas (up to 250 m long). Additionally, winding linear trenches and shallow quarries occur in surface obsidian outcrops. The general absence of occupation debris indicates that the prehistoric people who acquired obsidian moved to adjacent areas at lower elevations near water and shelter to establish camps and work the obsidian.

***Intensely burned landscape** shown here reveals partially infilled, single oval pit – an obsidian quarry feature.*

Fire damage at Obsidian Cliff affected the physical environment and modified the archeological landscape (artifacts and context) at each of the 59 loci. Alteration was greatest at those loci that were burned intensely. The loci without vegetative cover were subject to erosion. Indeed, erosion already was evident (9 months post-fire) at some intensely burned areas where runoff had resulted in incipient gullying and mass wasting. Elk and deer had put deep tracks in the softened cultural surfaces at several sites, mixing cultural materials. While the adverse effects of such bioturbation (mixing) were minimal, they did impact cultural deposits deprived of protective duff and understory ground cover. Fortunately, potentially destructive on-the-ground fire suppression activity was not undertaken on the flow itself.

The major factor widely affecting both the physical and archeological environments was the windthrowing of burned trees. (These are not called deadfalls, since many are still living; they toppled because organics in the soil, which supported the roots and held trees upright, were eliminated by burning.) Windthrown trees often pulled up large quantities (up to several cubic meters) of sediment, rocks, and cultural materials trapped within the root masses. The disturbance and disruption of site stratigraphy and associated artifactual context were evident in many such instances.

Modification to surface obsidian artifacts at intensely burned loci was variable, but in certain cases, substantial. Archeological bone and organics on or close to the surface at intensely burned cultural loci would have been severely damaged or destroyed by fire, much as ungulate skeletal remains were burned. Exposed archeological and geological obsidian often was head-fractured or exfoliated. Oxidized surfaces on a great number of obsidian artifacts at many burned loci were attributed to intense heating; oxidation appeared as a bright silver rind and a subtle dulling of rock surface.

Where obsidian was subjected to such heat, the internal structure commonly was modified. Such heating and oxidation of obsidian may prohibit, or complicate, the successful application of such technical studies as hydration dating and compositional analysis. The percentage of fire-fractured obsidian artifacts at most loci was low, but a large proportion of surface-exposed artifacts was oxidized.

Given the purposes of the 1989 archeological inventory and documentation project at Obsidian Cliff, the 1988 fire significantly enhanced both the long-range and short-range visibility of often subtle cultural features, loci, and artifacts. Pre-fire archeological reconnaissances of this heavily forested, dissected, high relief plateau had been severely hampered by accumulations of deadfall on steep slopes. Visibility through the forest itself was restricted to only a few meters by close-standing lodgepoles and a thick carpet of duff that masked the ground surface. The fire thus rendered visible a large number of archeological manifestations, exposing them to the possibility of vandalism.

In the last analysis, however, the 1988 fire and burnoff were opportune. The 1989 archeological reconnaissance, under post-fire conditions, provided basic primary data regarding quarry formation, lithic procurement strategies, and initial lithic reduction technology without the necessity of exposing artifacts, features, and activity areas by excavation.

The 1989 fieldwork yielded two major products: (1) the archeological inventory: (a) map of the Obsidian Cliff obsidian procurement site; (b) basic information regarding lithic extraction techniques employed by Native Americans; (c) a draft Obsidian Cliff National

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Fire History and Vegetation At Mesa Verde National Park

By Lisa Floyd-Hanna and Steve Budd-Jack

On July 8, 1989, a wildfire started on Long Mesa in Mesa Verde NP, and before the fire was controlled on July 27, it had burned 1,052 ha. As a result, several research agendas were pursued by the park staff and the Rocky Mountain Regional Office. Cultural resource personnel resurveyed the burn area, identified 9 new sites, and studied the effects of fire on surface and subsurface artifacts. Additional research began in 1991 to determine the past fire history of Mesa Verde NP and the pinon-juniper/shrub association. Following is a short update and review of that research, with special thanks to Dr. Will Romme of Fort Lewis College in assisting with project details and contributing to the methodology.

Mesa Verde NP is known for its extraordinary cultural resource, but it also occurs in a striking ecological setting. The mesa spans elevations of 1883 to 2612 m, and thus supports an array of vegetation types that include dominant pinon/juniper and Douglas fir stands. The role of fire in ecosystem patterning, both prior to and during the Anasazi occupation, is not known for this area of southwestern Colorado. The woodland, shrub, and forest types standing on the mesa today represent very different responses to fire. Ponderosa pine and Douglas fir may survive, and the shrub associations resprout vigorously after fire, their resprouting facilitated by frequent burning. Fire frequency and intensity have no doubt assisted in shaping the vegetation patterns found on Mesa Verde today. Such patterns are being used as keys to developing a fire history of the park.

In 1991, fire research focuses on two specific objectives. The first was to determine the vegetation patterns that have appeared since the 1989 fire on Long Mesa and in Long Canyon – a large fire impacted at least three different vegetation types; pinon/juniper woodland, shrub associations, and the Douglas fir/shrub association on the north escarpment. Three grid systems were established to sample vegetation that has resulted in each affected type.

The second objective for 1991 research was to develop a method for dating fires that occurred in the past. In southwest Colorado, Ponderosa pine (*Pinus ponderosse*) and Douglas fir (*Pseudotsuga menziesii*) are species that form fire scars and can be used to reconstruct fire history by traditional scar analysis. Unfortunately, very few trees of these species occur in Mesa Verda NP, and no fire scars have been located. The most abundant trees within the southern half of the mesa are pinon pine and Utah juniper, both of which are killed by fires.

We tested a method in which shrubs, which resprout vigorously after fire, were aged by annual ring counts to determine their time of origin. Dominant shrubs, Gambels oak (*Quercus gambelii*, Serviceberry (*Amelancheif utahensis*), Mountain mahogany (*Cercocarpus montanus*), and Fendlerbush (*Fendlera rubicola*), were sampled and aged in known historic fires (1934, 1959, 1972, and 1989). Although there is some variability within an individual as to the date of shoot emergence, we determined that by selecting the centermost shoot and restricting ourselves to the species *Quercus gambelii*, we are able to substantiate the known fire data within statistical reliability. *Fenlera rubicola* and *Cercocarpus montanus* also show promise for use in fire dating, but further analysis will be required to determine reliability of these dates.

During the 1991 field season, we will determine the stand origin dates of areas that are separated by clear discontinuities from adjacent vegetation. After incorporating the contribution of adaphic, exposure, or other factors, we will determine the date of potential fires resulting in each shrub community. The fire study will be closely tied to a vegetation community assessment, also to take place in 1992.

These two studies are complementary, since fire is a major shaper of vegetation patterning, and such patterning in turn influences fire behavior. Using aerial photos and other remotely sensed data, we will be preparing vegetation classification for filed verification in 1992. Methods used to ground truth the unsupervised classification of Landset imagery will be carried by the standard *releve* community analysis, similar to those being considered for general use in the Colorado Plateau national parks.

Dr. Floyd-Hanna is a biology professor at San Juan College in Farmington, NM and PI for two research projects at Mesa Verde; Budd-Jack is Resource Manager for Mesa Verda NP.

Obsidian Cliff

(Continued from page 26)

Historic Landmark nomination; and (2) an extensive compilation or sourcebook of Obsidian Cliff flow geochemistries and comparable data for archeological obsidian specimens from interior western North America sources.

Obsidian Cliff flow geochemistry was characterized from 80 specimens analyzed by non-destructive x-ray fluorescence for zinc (Zn), gallium (Ga), rubidium (Rb), strontium (Sr), yttrium (Y), zirconium (Zr), and niobium (Nb). The resulting elemental homogeneity of specimens within that sample, collected from within the 14.5 k2 flow, was both remarkable and informative. These quantitative data are in excellent agreement with previously published geochemical standards for Obsidian Cliff obsidian. The variability of most source-diagnostic trace elements is limited; bivariate scatter diagrams cluster paired trace elements tightly.

This sample is the best source-specific, geochemical profile available for Obsidian Cliff. These data and others obtained from montane and plains archeological sites in Montana, and from other even more distant sites that contain Obsidian Cliff obsidian, are summarized in a technical report available from the Rocky Mountain Region: *The Obsidian Cliff National Historic Landmark Lithic Source Area, Yellowstone NP: Geoarchaeological Baselines and Perspectives*, by Leslie B. Davis, Stephen A. Aaberg, and James G. Schmitt (1991).

Davis is professor of anthropology at MT/State/U and curator of archaeology and anthropology with the Museum of the Rockies; Aaberg is a consulting archaeologist in Billings, MT; Johnson is a staff archeologist, Division of Cultural Resources, Rocky Mountain Region, NPS.

Integrated Approach To Virgin Islands Research

(Continued from page 1)

Institute of Tropical Forestry, has been studying forest dynamics in the Cinnamon Bay watershed since 1983. Other research projects on vegetation include those by Anne Reilly (New York Botanical Garden and University of Georgia), Dr. Becky Brown and Gary Ray (University of Wisconsin), and Gary Ray and Dr. Francisco Dallmeier (Smithsonian Institution). Dr. Pedro Acevedo is preparing a comprehensive, illustrated "Flora of St. John" with full descriptions of the vascular plants and information on distributions and local uses. The Soil Conservation Service (John Davis, Bruce DuBee) is providing complementary data on the physical and chemical nature of the island's soils. Soil characteristics are a key factor in determining vegetation patterns and the extent to which plant species native to St. John will thrive or exotics prevail. SCS will be characterizing the soils associated with some of the long-term vegetation plots established on the island.

As part of the NPS Coral Reef Assessment Program, park biologists are studying the coral reefs in Lameshur and Newfound Bays, and Dr. Jim Beets from the U.S.V.I. Division of Fish and Wildlife is monitoring reef fish populations in Lameshur and other bays. Dr. Lisa Muehlstein from the University of Richmond is conducting research on seagrass beds. Beginning in January 1988, the park's research staff has been collecting valuable baseline data on water quality at 29 sites around the island. Since 1987, Dr. Robert Askins and Dr. David Ewert have been censusing migratory and resident birds on the island.

Many of these studies incorporate data from before and after Hurricane Hugo and help elucidate the response of ecosystems to "disturbance". For those of us who went through Hugo, it seems a bit of an understatement to refer to this storm as a "disturbance". On Sept. 15, 1989, two days before Hurricane Hugo hit the USVI, it had a wind speed of 306 kmh at an altitude of 500 m and a surface wind of 259 kmh. Hugo was therefore a category 5 storm before it hit St. Croix, about 56 km south of St. John. An estimated maximum surface wind of 223 kmh was reported as the eye passed over St. Croix on the night of September 17 to 18. The eye of the storm had a forward speed of only 14 kmh when moving over St.Croix, and the hurricane battered the USVI for over 12 h.

While changing some peoples' lives forever, Hurricane Hugo did provide an opportunity to study the effect of a major disturbance on the island's forests and marine systems and recovery after the storm. The data which have been collected on the vegetation, coral reefs, reef fishes, and birds since the storm are especially valuable because they can be compared to pre-storm data from permanent study sites in the forest and on the reefs.

Research in the park is providing data that fill in gaps in our basic knowledge of the ecosystems of St. John but also have significance for other tropical sites (particularly other Caribbean islands) with similar resources. For example, the park has the largest remaining tract of tropical dry forest within a protected area in the Eastern Caribbean. Also, Virgin Islands National Park is one of the few areas in the Caribbean where forests that were cleared are being allowed to recover.

(Concluded on back cover)

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Little systematic information exists on soil moisture and temperature anywhere in the Caribbean. Recent research on the bird populations suggests that the island has some of the highest densities of migratory warblers in the Caribbean and a higher density of these songbirds than on the nearby island of St. Thomas which is highly developed and has little intact natural habitat. Askins et al. (1990) point out that "only a few long-term studies of birds have been accompanied by periodic analysis of vegetation in the study site". Data from the permanent vegetation plots are therefore enhancing the information on resident and migrant birds on St. John. Dr. Askins and Dr. Dave Ewert also are learning more about the relationship between forest area (size) and composition of bird communities. This work provides a basis for land-use decisions, showing the danger of fragmenting the forest and creating isolated patches of vegetation.

Botanical studies have shown that previous assumptions about elimination of plant species as a result of deforestation during the plantation era of the 1700s and 1800s are not valid. Current research suggests that few if any species were lost, but the relative abundance of native and introduced species has changed.

Throughout the Caribbean, degradation of marine systems is accompanying careless development of coastlines and upland areas. The Park Service is just beginning a cooperative study with the U.S.G.S. to compare sediment loads from one developed and one undeveloped watershed on St. John. Information on the erodibility of soils from the SCS study will also be useful for developing models of watershed processes.

While the primary objectives of the studies differ, together they represent an integrated approach to the management of natural resources in the biosphere reserve. There has been remarkably close cooperation and communication among the different investigators. The studies provide complementary data sets which allow the researchers to make better use of their own data and to extrapolate their findings to other sites in the Caribbean. The more we study St. John, the more we appreciate the value of Virgin Islands National Park and Biosphere Reserve. Though the park is small, the knowledge gained from its research program can contribute to our ability to protect marine and terrestrial resources in tropical environments.

Rogers is NPS Research Biologist at Virgin Islands NP.

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Inventory and Monitoring in the National Parks: Forging a Plan

By June C. Rugh and David L. Peterson

The National Park Service will assemble baseline inventory data describing the natural resources under its stewardship and will ***monitor*** *those resources ... to detect or predict changes. The resulting information will be analyzed to detect changes that may require intervention and to provide reference points for comparison with other, more altered environments [emphases added].*

– Management Policies. Chapter 4:4, 1988

The NPS policy statement above marks a turning point in the long history of resource inventory and monitoring in national parks. For although inventory and monitoring (I&M) activities – species checklists, visitor counts, weather records – have been conducted in individual parks since the 1870s, only recently has there been an effort to establish a more rigorous and integrated approach to these endeavors. The impetus behind this effort is threefold. First, multiple environmental stresses on parks (including human use, air pollution, introduced species, and a changing global climate) are increasing at an unprecedented rate, making reliable scientific data imperative for effective resource management. Second, there is a growing recognition that coordinating and standardizing I&M activities throughout the NPS would enable managers to track resource conditions on an interpark and nationwide basis, ultimately yielding a higher quality of both I&M data and managerial decision-making. Finally, it is generally acknowledged that for I&M programs to be successful in the long term, the responsibility for coordinating these activities must be tied to positions rather than individuals: they must be incorporated into the NPS organizational structure.

While the NPS is committed to the concept of improved inventory and monitoring, there have been no systematic guidelines until now (see shaded box). Resource managers also need a standardized planning strategy to help them in developing individual park I&M programs. The planning strategy should 1) be generic enough to accommodate a variety of objectives and resolution levels, 2) assist managers with decision-making, including improved quantification, and 3) be flexible enough to be easily modified and updated. The development of such an approach is part of an ongoing research effort by the Pacific Northwest Region to improve I&M programs in the NPS. Research Biologist David L. Peterson and Research Associate David L. Silsbee are directing this effort at the U/WA CPSU, in cooperation with Daniel L. Schmoldt of the USDA Forest Service, Blacksburg, VA. The planning approach developed by this research team emphasizes the following components:

This article (the first in a series of two) represents a research effort on the part of the Pacific Northwest Region to offer an approach for developing a dynamic, technically rigorous inventory & monitoring program within each park. Based on state-of-the art methods and analyses, it offers practical strategy and support tools that will facilitate I&M program development among parks. One sign of NPS's renewed commitment to I&M is the recent appointment of Gary Williams to the newly created position of Director of the Service-wide Inventory & Monitoring Program at WASO. A general conceptual model of the inventory and monitoring process appears in the recently published *Natural Resources Inventory & Monitoring Guideline* – NPS-75. For more information, contact Gary Williams, (202) 208-5193.

– An **interdisciplinary team approach** to I&M program development

– **Standardized project description** and **classification**

– **Development strategy:** objectives and attributes of I&M projects

– **Quality assurance** and **data management considerations**

– **Support tools** for prioritizing, planning, and allocating resources to I&M projects.

This approach can be used to develop a new I&M program or to modify an existing one. The **interdisciplinary team** of scientists and resource managers would work together intensively to develop program objectives and write a comprehensive I&M plan for the individual park. Standardized **project descriptions** and **classifications** establish a conceptual and technical basis for prioritization and implementation, as well as insuring consistency among parks. **Development strategy** for I&M programs focuses on the objectives and attributes of each project as the keys to implementation. **Quality assurance** and **data management considerations** are addressed as essential factors in maintaining the integrity and scientific validity of each proposed I&M program. Finally, the **support tools** consist of decision-making strategy (the Analytic Hierarchy Process) and interactive computer software, both of which employ a quantitative rating system to assist in planning and prioritizing I&M projects. The same tools serve in the allocation of resources for I&M projects, which is optimized by including information on budget and personnel requirements as part of evaluating and selecting projects. *This final section on I&M support tools will appear in the next issue of* ***Park Science****.*

Interdisciplinary Planning: the Team, the Tools, the Process

One of the most useful innovations in the works is the development of an I&M interdisciplinary planning

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Figure 1. *Interdisciplinary team process for developing an I&M plan.*

I. INITIATION OF PROCESS: *Park staff*
Contact I&M team leader;
provide materials

II. WORKSHOP: *I&M team & park staff*
Overview; brainstorming;
final project list; descriptions

III. I&M PLAN DRAFT: *I&M team leader & park staff*
Compilation of project descriptions;
overview; tables; references

IV. REVIEW: *I&M team, park staff, & others*
Circulation of draft for review

V. FINAL I&M PLAN: *I&M team leader & park staff*
Final plan written, after reviews

PARK SCIENCE
NATIONAL PARK SERVICE

FALL 1992

A report to park managers of recent and on-going research in parks with emphasis on its implications for planning and management

ARTICLES

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editorial

If you build it, they will come.

Watchable Wildlife was the movement; a stylized set of binoculars was the logo; and they came – 400 strong, from all over the U.S. and even from Canada and Mexico – to the 1st National Watchable Wildlife Conference, Sept. 10-12 in Missoula, MT.

For three jam-packed days, representatives of eco-tourism, and federal and state agencies with fish, game, and/or recreation interests, interacted both inside and outside of 34 intensive working sessions. The subjects covered almost every conceivable way of incorporating watchable wildlife into entertainment, enjoyment, education, the economy, and ethics. Whether the individual conferees came motivated to make money or to promote biological diversity, the watchable wildlife theme was inclusive and binding.

Fifteen entities – federal agencies (including the National Park Service) and conservation organizations – were signators to the Memorandum of Understanding that supports the movement, but none of the 15 evidenced a "guiding hand." Rather, it was the yeasty mix of celebrants, eager to share information and success stories, that provided the conference signature. The working sessions showcased story after story testifying to the public hunger to be involved in wildlife activities.

Hal Salwasser, formerly a deputy director of the U.S. Forest Service and soon to be the Boone and Crockett professor of forestry at U/MT, sounded the upbeat conference note in closing:

"Don't lose the magic," he said. "You're building a coalition here of public and private sectors that can do more than any legislation. You aren't dependent on any agency or leadership group or pot of dollars. You're people from many different places and interests, bringing meager resources to the table and making of them something much larger than the sum of the parts.

"You're excited. You're having fun. You're pulling together. You represent a promising alternative to polarization. You have the enormous task of recreating the old sense of community whose actions are based on collective self-interest.

"So celebrate your successes; share your information. These are goals enough for now."

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The NPS has produced a Watchable Wildlife brochure that will be ready for distribution by November 1. The 4-color 16 x 16½" folder was funded by the NPS Foundation and the National Fish and Wildlife Foundation. It describes some of the wildlife that can be seen in the 10 NPS Regions.

Forging a Plan for I&M in National Parks

(continued from page 1)

team at the regional level. Composed of regional office personnel, field unit resource managers, and scientists from CPSUs – as well as experts from outside sources – the team would bring a wide range of professional knowledge to park I&M planning efforts. Working through a five-step process, team members would help resource management staff conduct a thorough review of the management and scientific aspects of I&M projects for the park, while keeping in mind the broader goals of the region and the NPS. Typically, the region's I&M coordinator (already in place or soon to be named in most regions) would be the team leader, overseeing a 10-member group with proven expertise in areas such as terrestrial, aquatic, and wildlife biology, social science, cultural resources, and resource management. One or more team members would also be proficient in quality assurance procedures and data management; other experts would be invited to participate as needed.

As indicated in Figure 1, the initiative to begin the process would come from the park's own resource management staff. On anticipating the need for developing (or revising) an I&M plan, the park's I&M coordinator (i.e., the resource manager with lead responsibility for I&M activities) would contact the regional I&M team leader, also providing the team with enough background material to establish a working familiarity with the park's resources, existing data, and current concerns. The park staff would then convene a workshop, preferably on-site, attended by the I&M team and selected members of the resource management staff. Following an overview, conducted by park staff on resources, scientific issues, and managerial concerns, including field site visits, the team leader would direct workshop participants through these phases: a brainstorming session to voice and record all ideas relevant to I&M concerns; organizing a list of potential I&M projects; establishing a final, consensual list of I&M projects; and writing a detailed description of each proposed project. The team leader also would introduce planning and decision support tools, including the Analytic Hierarchy Process and related software, and would demonstrate applications for prioritizing projects and optimizing resource allocation.

At this point, park staff participants would be encouraged to draw on the available expertise for rating projects.These ratings would serve as input for park resource management staff, who would have the final word on project prioritization. Following the workshop, the team leader would compile completed project descriptions into a draft I&M plan, including a table of projects with estimated budget and personnel requirements, reference material, and an overview statement prepared in conjunction with park staff. This draft plan would then be circulated for review among the I&M team, park staff, and other appropriate NPS staff. Other interested parties, such as agencies with adjacent land ownership, also would be included in the review process. After consideration of these reviews, the final I&M plan would be prepared by the I&M leader and park staff.

In essence, the interdisciplinary planning group would serve as a "SWAT team," bringing in expert knowledge and tactics to expedite the process and enable resource managers to design I&M programs with the greatest efficiency, consistency, and suitability.

Project Description and Classification: Finding A Common Language & Organizational Framework

The list of projects developed by the interdisciplinary team must include enough data for each project to provide a conceptual and technical basis for prioritization and implementation. Moreover, individual project descriptions must use a common language in order to guarantee consistency among parks and optimal usefulness within the NPS. To this end, Peterson et al. (1992) have developed a taxonomy of resource categories to be used in I&M planning. At the most general level, the categories consist of headings such as "Atmospheric," "Geologic," "Hydrologic," "Flora," "Fauna," and so on. Subcategories lend further precision, so that the full resource classification for one I&M project might read "Human Activity > recreation > backcountry use > impacts > aquatic resources," with the final subcategory being the most specific, and the full sequence representing a precise picture of the resource in question. Along with taxonomic classification, each project also is classified according to "level of effort" – the amount of effort required to obtain the information required for I&M planning. The three specific levels of effort are: 1) compile existing information, 2) conduct resource inventories, and 3) establish monitoring.

The current as well as the planned level of effort should be indicated. For example, a park that wishes to determine the effects of air pollution on plant species may already have some data on sensitive species (*current:* "compile existing information"), but would like to determine if other sensitive species are present (*planned:* "conduct resource inventories") and evaluate visible symptoms for several years (*planned:* "establish monitoring"). The first level, "compile existing information," does not actually in volve any inventory or monitoring of resources. It is nevertheless important both because it prevents wasting time and money collecting information already available and because it provides clues to gaps in data that an I&M project typically encounters. For a full discussion of the specific methods involved at each level of effort, see Peterson et al. (1992). The resource categories and level of effort designations should be considered an organizational framework for classifying and identifying I&M projects in preparation for the subsequent steps of prioritizing, decision-making, and allocating resources.

Development Strategy: Defining Objectives and Selecting Attributes

The first hurdle in developing an I&M program is defining objectives. Only then can decision-makers move on to deciding which attributes (e.g., air quality, species) to inventory and monitor, and which monitoring protocols to apply. The most common objective is to use I&M information to enable managers to make better informed management decisions. For example, the impact of park visitors on vegetation can be monitored to determine whether changes in visitor management strategies are needed. Another typical objective would be to use I&M information to convince others to make decisions benefiting parks. As shown in Figure 2, the list of major I&M objectives extends to eight, and each of these can be described in concise, functional terms (e.g., "Inform internal decision-makers"). Figure 2 also delineates the relationship between each objective and its respective attributes selection.

Decisions regarding which specific attributes to monitor, and at what level the monitoring should be done, are determined by the governing objective. Inventory and monitoring can be done at any level, from individual organisms to entire ecosystems. A program with the objective of providing early warnings for global or regional problems, for instance, would require focusing on stresses appearing at the individual and

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Figure 2. I&M Objectives and Attributes Selection

Objectives	Attributes Selection
Inform internal decision makers	Attributes involved in specific management decisions
Influence external decision makers	Attributes most likely to show effects of outside activities
Satisfy legal requirements	Determined by legal requirements
Maintain familiarity with resources	Attributes most sensitive to change
Provide better understanding of resources	Broad spectrum of attributes
Provide background information	Attributes of day-to-day interest to visitors and others
Provide early warning of global or regional problems	Attributes most likely to show detectable change
Provide background data for exploited areas	Attributes of interest in managing outside areas

GIS Analysis Determines Erosion Potential At Buffalo National River Basin

By Tim Stephenson and David Mott

Land use activities in the hilly terrain of the Ozark Plateaus have resulted in widespread erosion at least since the mid 1800s. The principal endeavors here in the late 19th and early 20th centuries were logging, open grazing of hogs, and row cropping in flood plains. More recently, conversion of forest to pasture is the dominant activity.

Because the Ozark region is dominated by limestone and dolomitic rock types, which typically produce poor soils with a high proportion of gravel sized chert, the dominant land derived sediment resulting from this erosion is soil and gravel. As a result of the gravel's size and mass, it has a relatively long residence time in the surface hydrologic system. According to Jacobson and others (1990), erosion and transportation of sediments has caused Ozark streams to exhibit gravel aggradation and resultant channel instability. By comparing recent and prehistoric periods of aggradation, these authors have concluded that the recent episodes appear to be much more severe.

Aggradation of channel sediments and clearing of

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I&M in National Parks

Continued from page 3

population level, where these effects would appear sooner than at the community or ecosystem level. Determining which species to monitor involves yet another set of criteria and considerations (for specifics, see Silsbee and Peterson (1991). Developing specific monitoring protocols for selected ecosystem attributes is relatively straightforward, dictated by cost limitations and the intensity of sampling needed to give useful results.

Throughout this decision-making process, the development of an I&M plan can be expedited and enhanced by using the Analytic Hierarchy Process and the supporting software, Expert Choice[1] (these support tools will be discussed in depth in the subsequent article). Placing the objective (or "goal") at the top of the hierarchy, managers – with the help of the I&M team leader and Expert Choice – can change values randomly or systematically to see how changes in the objective would shift priorities down the line. For example, the relative importance of "support of resource management decision-making" could be high in one case and low in another. Or an emphasis on "provide background information" could be replaced by an emphasis on "satisfy legal mandates." This exercise enables a manager to determine how different management objectives would affect overall project rankings; changing just one element of the hierarchy might cause one project to rise, and another to drop, within the I&M program as a whole. The large and varied amount of information encompassed by the Analytic Hierarchy Process/Expert Choice model structure thus permits a resource manager to examine the conceptual basis for I&M project development and prioritization from many angles, and in great detail.

Quality Assurance and Data Management Considerations: Preserving the Integrity of the Program

A strong quality assurance (QA) program is the cornerstone of credibility for I&M efforts and insures that I&M data will stand up in a court of law, if necessary. QA provides continuity and consistency over time, among different employees, and through changes in management and personnel. This is particularly crucial for monitoring programs which compare data collected by a variety of people over a long period of time. In the context of an I&M program, QA focuses on the design of a program appropriate to the stated objectives, including the identification and resolution of potential quality assurance problems. Specialized experimental designs may or may not be necessary, but thorough documentation of project objectives, design, and methods is always vital to a QA program. Documentation of the precision and accuracy of all measurements used in I&M activities also is essential.

Each park's I&M coordinator must be aware of QA concerns and address them explicitly. It is advisable to work with a statistician (as part of the I&M team, or brought in separately) concerning study design, sampling, and statistical analysis. Similarly, scientists with expertise in QA should be contacted for help in developing protocols for the park's I&M projects. Advice on specific QA protocols can be obtained through NPS divisions such as the Air Quality and Water Quality Divisions; other agencies, particularly the EPA, also have expertise in this area.

Every I&M project should include a QA document that correlates with the other elements of the overall I&M plan. The QA plan should include 1) a *description* that explains and justifies the overall approach to the project, including objectives, methods, scope, statistical treatment, and the project's relationship to other studies; and 2) a *methods manual*, including site selection, sampling protocols, data sheets, documentation of precision and accuracy, and data analysis and reporting. Careful documentation must continue throughout the duration of each I&M project, and should include: site descriptions and observations; explanations of deviations from sampling methods; sampling dates and personnel; periodic precision and methods checks of all methods and personnel; and data storage, including frequent duplication and security measures.

Sound data management measures, in turn, are the key to successful QA. The objectives of data management are to insure that 1) data are stored and transferred accurately, and 2) data are secured from loss or damage. Moreover, the structures and format of the data must be documented with sufficient detail so that someone not versed in the original project could interpret their meaning and evaluate their accuracy and precision. For recommended data management measures, see Peterson et al. (1992).

Although the QA and data management aspects of I&M can sound burdensome, they are critical to making a park's I&M program technically sound, credible, and defensible. If such measures are instituted at the start of each I&M project, they will become a routine part of its operation. Because every park unit will not have the expertise to develop QA and data management procedures on its own, it is vital to identify cooperators who have background in this area; this includes personnel from other parks or regional offices and various NPS divisions, as well as from other agencies and universities. Such outreach efforts can open doors to cooperators who would be interested in participating in I&M projects, and can also add facets to the program that the park itself cannot fund. Ultimately, the completeness of QA and data management must be balanced against available funding and labor.

A Commitment to I&M: Envisioning the Future

The practical strategy and support tools being developed by the Pacific Northwest Region offer an approach for developing an adaptable, technically rigorous program within each park, based on up-to-date methods and analyses. They provide a consistent framework that will assist in standardizing I&M program development among parks on a regional and national basis. In addition, this approach encourages interaction among different units within and outside NPS, in order to address a wide range of scientific and managerial concerns.

The most striking sign of NPS's growing commitment to I&M is the newly created position of Servicewide Inventory & Monitoring Program Director at WASO. As Program Director, Gary Williams has helped to produce the newly published *Natural Resource Inventory and Monitoring Guideline, NPS – 75.* When asked to define the driving force behind current I&M efforts, Williams quotes from the new *Guideline:* "Preserving the natural resources (and natural processes) in the National Parks may be the most important legacy the Park Service can provide American conservation."[2] In fact, a comprehensive NPS resource I&M program would be unique among such programs in the U.S. and throughout the world. Current programs outside NPS either monitor a wide variety of ecological parameters within small areas (as in experimental forests) or apply a narrow suite of measurements across large areas or networked sites for specific data needs (as in acid precipitation monitoring). The envisioned NPS program would apply a broad spectrum of ecological measurements to a large and diverse area. Moreover, information gleaned from I&M data would be valuable to many research programs that address issues within NPS and beyond, such as the Global Change Research Program. Successful development and administration of an I&M program of the magnitude presented here would provide a model for other agencies and institutions. In this way, NPS can seize the opportunity to be a national and global leader in I&M planning.

[1]Tradenames are used for information purposes only. No endorsement by the U.S. Department of the Interior is implied.

[2] Natural Resources Inventory and Monitoring Guideline, NPS-75.

Rugh is a technical writer and Peterson is a Research Biologist at the U/WA CPSU, Seattle.

The following publications are available from the Cooperative Park Studies Unit, AR-10, University of Washington, Seattle, WA 98195:

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Schmoldt, D.L., D.L. Peterson, and D.G. Silsbee. 1992. Strategic inventory and monitoring programs: prioritizing projects and allocating expenditures. Manuscript submitted for publication.

Silsbee, D.G.. and D.L Peterson. 1991. Designing and implementing comprehensive long-term inventory and monitoring programs for National Park System lands. Natural Resources. Rep. NRR-91/04. National Park Service, Denver, CO.

Gravel aggradation and streambank erosion *in a tributary to the Buffalo National River result from upland clearing and removal of riparian vegetation.*

riparian vegetation for agriculture have caused increased channel instability, anastomosing (dividing and reuniting), shallowing and widening (Jacobson and Pugh, 1992). As a result, there is evidence that significant changes are occurring in the physical habitats that influence aquatic ecosysstems. This study uses a GIS to define the land use change in relation to slope in a portion of the Buffalo National River Basin and to interpret the potential for upland erosion and gravel transport.

The Watershed

Buffalo National River (BUFF) was established as the nation's first National River in 1972 for "preserving as a free-flowing stream an important segment of the Buffalo River in Arkansas . . ." (P.L. 92-237). In reality, BUFF is a narrow corridor straddling the river and averaging 2 miles in width. It comprises only 11 percent (95,730 acres) of the total watershed area (840,000 acres). The park is extremely susceptible to water resource degradation from external sources and lies downstream from all the diverse land use activities and pollution sources within the watershed.

As with many Ozark streams, the Buffalo River is in a state of disequilibrium. Because of its relatively steeper topography, greater magnitude of peak flood events, and gravel inputs from three different plateau systems, the Buffalo River may be among the most impacted streams from current and past land use changes. Gravel aggradation and clearing of riparian vegetation have resulted in widespread erosion affecting from 10 to 15 percent of the river corridor.

Methodology

The study unit encompasses 4,170 acres of private property in the Springfield Plateau region of the drainage basin. The area is sparsely populated and characterized by sharply defined valleys containing small streams separating flot topped ridges. Land use data from 1965, 1974, and 1979 were analyzed by Nyquist (1982), to an accuracy of 0.09 percent of the total acreage. The land use data for 1983 were digitized at the University of Central Arkansas (UCA) from aerial photography provided by the Arkansas Highway and Transportation Department. The slope characteristics were derived from elevation data digitized at UCA from USGS 7.5 minute quadrangle maps.

Studies by El-Swaify and others (1985), indicate that on slopes greater than 7 degrees, overland flow is the major causal factor in the detachment of soil components. Clearing of forests and conversion to pasture greatly increase the overland flow component of a given precipitation event. A GIS analysis was employed, based on these physical processes, to determine the relative rate of conversion on 3 different slope regimes over 4 discrete time intervals.

Results

Nyquist (1982) studied the land use changes occurring in the entire Buffalo River watershed from 1965 to 1979 and determined that "the rate of conversion (from forest to agriculture) was nearly halved in the years 1974 – 1979." A summary of the data generated by this study is given in Table 1 and indicates the amount of cleared land increased by 126 percent from 1965 to 1983. Although this study corroborates Nyquist's findings of a decrese in the rate of conversion from 1974 to 1979 in the smaller study area, this appears to represent only a temporary slowdown in the conversion rate as opposed to any long-lasting trend.

As of 1965, 770 acres of the study area were in pasture, with 39 percent of this area on slopes greater than 7 degrees. An additional 962 acres had been cleared by 1983, with 50 percent of the conversion taking place on slopes greater than 7 degrees.

During the 18-year study period, the amount of land cleared for pasture on slopes less than 7 degrees increased by 103 percent, while conversion on slopes of greater than 7 degrees increased by 160 percent. Given the erodible characteristics of the areas being cleared on the steeper slopes, plus the fact that these areas are being cleared at an increased rate, significant potential exists for further loading of gravel from highland areas and associated degradation of stream geomorphology.

The increased conversion on steeper slopes apparently results from several factors, among which are a lack of available level land and an upswing in the cattle market. While results of this analysis are not intended to be conclusive, due to the limited size of the study area, they are consistent with general field observations. Because of the importance of land use trends to BUFF's water resources, further research covering more of the watershed and using more current data is warranted.

Stephenson is a geography student at UCA, Conway, Ark.; Mott is Hydrologist at Buffalo National River, Harrison, Ark.

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Poor soils and steep slopes *combine to produce large volumes of gravel, which are transported by heavy rains to the surface hydrologlic system at Buffalo River.*

Table 1. Summary of land use and slope data.

	Acres Converted			
Time Period	All Slopes	0 to 7 Degrees	7 to 14 Degrees	14 to 35 Degrees
1965	769	467	202	97
1965-1974	438	237	118	82
1974-1979	151	62	51	38
1979-1983	373	182	104	87
1965-1983	962	481	273	207

Assessing Nonpoint Sources of Toxicity Part II: Using Biomonitoring Techniques

By Del Wayne Nimmo, John Karish, Heidi Bestgen, Trudy Steidl-Pulley, Mary Willox, Terri Craig, and Carla Castle

"What happens outside the parks dramatically affects what happens inside them." (Kerwin 1991).

Encroachment on our national parks by an "array of executioners: builders, commercial developers, recreation lovers, ranchers, miners, and thirsty, smoggy cities" (Kerwin 1991) is a common concern in all fields of resource management. Nowhere is this more obvious than in the field of water quality assessment. The complex problem of protecting water quality facing our nation today is especially felt in our national parks, where the goals are to maintain pristine conditions and the highest standards. As a result, most people visiting parks believe they have entered an isolated, uncontaminated "biosphere."

Unfortunately, this is not the case. What happens to water **before** it enters parks controls the quality of water **within;** parks are dependent upon this water regardless of where it comes from or its condition. The most insidious threat is from nonpoint source pollution (i.e. pollution neither enclosed in a pipe or conveyance nor subject to federal or state effluent limitations).

How to confront these nonpoint source issues seems to be the "$64,000 question." The scientific complexity of the watershed, surface and subsurface geology, and the sociopolitical complexity of land use surrounding parks makes the protection of water quality a formidable task. It is even more difficult to address the interaction of individual pollutants with the physical characteristics (i.e., pH, dissolved oxygen) of natural waters. In an effort to address these complex concerns, we have developed and initiated various pilot biomonitoring programs (see ***Park Science***, 12:3, pp. 26-28) in five national parks, each with differing nonpoint source water quality problems (Table 1).

The issues and questions affecting these parks present scientists and managers with various challenges for designing early-warning programs to detect, test, collect, analyze, and present the evidence for nonpoint source pollution. **Biomonitoring** assists in assessing nonpoint source pollution problems by: (1) helping to maintain objectivity when addressing water quality, (2) targeting and/or prioritizing suspected problems, (3) aiding in identifying and prioritizing future sampling sites, (4) identifying certain toxicants (when used in conjunction with chemical analysis) at a particular sampling location, and (5) helping, cost effectively, to discover and understand the causes of water quality impairments.

Biomonitoring is an objective way to address water quality issues. This was the case with the Namekagon River, St. Croix National Scenic Riverway (SACN), and an unnamed creek within the Ft. Darling Unit of the Richmond National Battlefield Park (RICH). At the Namekagon River, the test water looked "healthy" (clear, with vegetation and insect activity), but biomonitoring – using daphnids and fathead minnows – indicated that water quality problems existed. First, there were significant decreases in the reproduction of daphnids in waters coming from two of the three cranberry marshes (Sites 3 and 5, Fig. 1). Second, at Site 5, only 50 percent of the larval fathead minnows survived the 96-hour *in situ* exposure compared to 100 percent that survived at Site 6, which receives substantial dilution from a larger unimpacted tributary – Potato Creek. In contrast, at the Neimitz marsh (Sites 7, 8, and 9), daphnids reproduced better than average and the minnows survived at an average of 87 percent, giving no evidence of impact from the cranberry marshes located there. Data gathered from these biomonitoring studies therefore, suggest that further investigation of Sites 4 and 5 is warranted.

Biomonitoring assessment of an unsightly creek in the Ft. Darling Unit (RICH), also gave an objective indication of water quality. Here, unlike the Namekagon studies where all the water samples **looked** "healthy," extreme turbidity and an intense rust color from leachates seeping into the creek out of a nearby landfill obviously suggested impaired conditions. But biomonitoring indicated that substances in the leachates, contrary to assumptions, were not toxic to the daphnids, amphipods, or minnows in the initial tests or in chronic toxicity tests with daphnids in later studies (Fig. 2). Because of the results from these studies, we were able to conclude that the absence of aquatic life in the creek probably was due to thick, soft sediment-oxides and not, as first believed, to toxic chemicals from the landfill.

In addition to objectivity, biomonitoring can target and/or prioritize already suspected problem areas in parks. For instance, information gained in an Everglades NP (EVER) study, using daphnids, minnows, and feeding rates of amphipods, suggested that specific canals were impaired and should be selected for

Table 1. *Locations where nonpoint, biomonitoring, pilot programs were conducted.*

I. ST. CROIX NATIONAL SCENIC RIVERWAY (SACN)	
SITE:	The Namekagon River, a tributary to the St. Croix River, Hayward, Wisconsin.
ISSUE:	Nonpoint sources from extensive commercial cranberry marshes.
QUESTION:	Are pesticides and/or nutrients entering the Namekagon River?
II. RICHMOND NATIONAL BATTLEFIELD PARK (RICH)	
SITE:	The Fort Darling Unit near Richmond, Virginia.
ISSUE:	Nonpoint source from a landfill contained within the park.
QUESTION:	Are leachates from the landfill, which have severely discolored the sediments of an unnamed creek within the park, toxic to aquatic species?
III. EVERGLADES NATIONAL PARK (EVER)	
SITE:	Southern Florida.
ISSUE:	Nonpoint sources from encroaching agriculture and urbanization.
QUESTION:	Two problems currently being addressed are: (1) the high concentrations of mercury identified in both the bass and the endangered Florida Panther within the park (Simons 1991; Loftus 1990), and (2) the rapid die-off rate of the park's native vegetation (Robblee and DiDomenico 1991). How can the park incorporate biomonitoring to address these problems?
IV. UPPER DELAWARE SCENIC AND RECREATIONAL RIVER (UPDE)	
SITE:	Narrowsburg, New York.
ISSUE:	Nonpoint source from a nearby Superfund landfill.
QUESTION:	Are leachates from the landfill, which have been discoloring the river sediments, toxic to aquatic species?
V. WILSON'S CREEK NATIONAL BATTLEFIELD (WICR)	
SITE:	Near Springfield, Missouri.
ISSUE:	Nonpoint sources from increasing nearby urbanization.
QUESTION:	Is the rapid urbanization of Springfield affecting the quality of water in Wilson's Creek within the park?

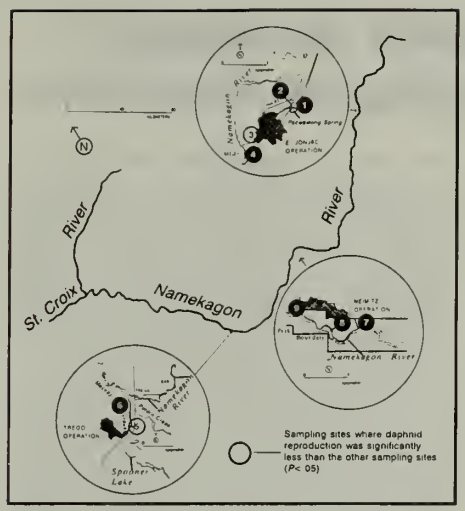

Figure 1. *Locations of cranberry marshes and biomonitoring sites along the Namekagon River, St. Croix National Scenic Riverway, Wisconsin. Sites 1, 2, 6 and 7 are reference sites which were either above the influence of the cranberry operations or, as with site 6, greatly diluted by another tributary.*

further in-depth studies. By ranking the three test endpoints (eating rate of amphipods, growth rate of larval fathead minnows, and reproduction rate of *Ceriodaphnia dubia*) and subdividing the ranks into good, fair, and poor (Fig. 3), an association between endpoint ranks and water quality was made 74 percent of the time. This led to prioritization of suspected problems and reevalution of chosen controls.

Pineglades Lake, for example (Site 1, Fig. 3), because of its central location, isolation from direct surfacewater (canals) or groundwater, and history of good water quality, was initially considered as a control site

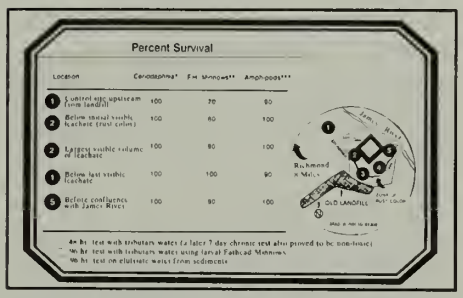

Figure 2. *Percent survival of test species exposed to water and sediments from one control site upstream and four sample sites downstream from a landfill in a small unnamed creek, Richmond National Battlefield Park, Virginia.*

for the studies; however, it ranked lower than expected. Thus, based on higher ranking, other lakes and canals in the park were targeted as more appropriate controls for future studies. Endpoint ranking also uncovered severely impacted water in need of high, immediate prioritization. Exposure to waters from canal sites L-28Tm and S-12C, endpoint ranked "poor," caused spinal deformation in a few of the larval fathead minnows tested – a condition seen only in severely impacted waters.

Using known test data, biomonitoring can aid in identifying and prioritizing toxic sampling sites for future biomonitoring studies. Eight samples of leachates entering the Upper Delaware Scenic and Recreational River (UPDE) from a nearby landfill were shipped to a cooperating laboratory. Toxicity was detected in five, three, and two samples using daphnids, larval fathead minnows, and amphipods and grass seeds respectively. However, a question arose about many more seeps located upstream and downstream from the landfill that were not tested due to limitations of lab space, time, and money.

The question was, could we conduct biomonitoring tests and use the information to prioritize the leachate areas based on toxicity? Thus, a second series of tests was conducted on site with the daphnids; results indicated that all the leachates, except at field reference site C1 (surfacing upstream from the landfill at the river's edge), were acutely or chronically toxic to the daphnids (Fig. 4). Among the toxic sites identified were A.S., a spring with substantial flow, and C2, the most toxic seep, where 92 percent of the daphnids died within 12 hours. Another sample collected from C2 was shipped to a cooperating laboratory, where its toxicity to fish and grass seeds was identified. Additional chemical analysis of the C2 leachate detected the presence of acetone, methylene chloride, and ammonia.

Another important toxic site identified was C9, which because of its "healthy" color, was previously believed to be downstream from the leachate influence. Findings therefore indicated that (1) data from the onsite daphnid studies were useful in prioritizing the locations of leachates for more in-depth analysis, (2) assessments of toxicity should be made with a variety of test organisms, in this case daphnids, minnows, amphipods and grass seeds for a complete confirmation and understanding of the biological impact, and (3) without toxicity testing, a full comprehension of the toxicity of all the leachate sites would not have been disclosed, including C9, which at first had appeared to be unimpacted.

Living organisms can be used in conjuntion with chemical analyses to identify certain toxicants affecting water quality at a particular sampling location. Earlier biomonitoring investigations of tributaries, springs, and segments of the Wilson's Creek watershed, conducted during two different seasons within two years at Wilson's Creek National Battlefield (Nimmo et al., 1992), suggested that water collected from Site 6, above the park, was toxic to daphnids each time tests were conducted (Fig. 5). Next, biomonitoring plus Toxicity Identification Evaluation (TIE) procedures were

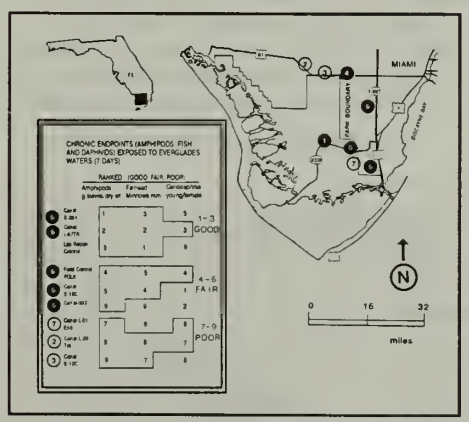

Figure 3. *Locations of biomonitoring sites in Everglades National Park, Florida. The insert shows the relative ranking (good, fair, poor) of those sites based on three chronic test endpoints (feeding rate of amphipods, growth rate of larval Fathead Minnows, and reproduction rate of Ceriodaphnia dubia). Blocks represent endpoint agreement among the three categories. Closed circles represent those sites that ranked in the "good" or "fair" categories whereas sites ranked in the "poor" category are shown as open circles.*

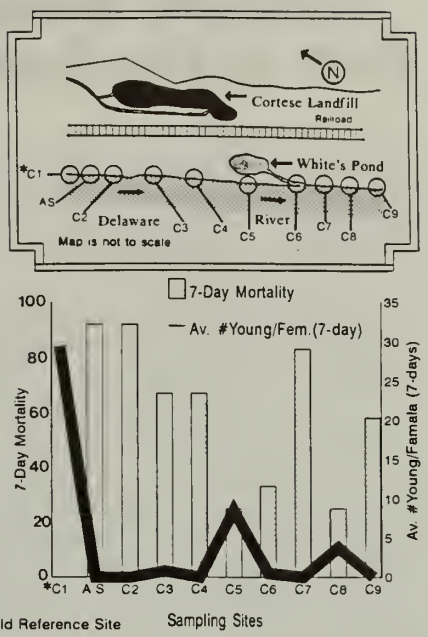

Figure 4. *Biomonitoring sample sites of leachates entering the Delaware River (Upper Delaware Scenic and Recreational River, New York) below a Superfund landfill. Data shown in the bar graph represent the 7-day mortality of the test species,* Ceriodaphnia dubia, *and the line graph represents the average number of young produced per female* dubia *that survived the exposure after 7 days.*

planned. These procedures join biomonitoring with lab tests to identify the physical and chemical characteristics of the substances believed to be toxic. Eventually, after biomonitoring and TIEs were conducted, the appropriate analytical techniques were chosen to verify the toxicant(s) responsible for the toxicity. The data gained from Site 6 indicated that when metals (copper, nickel, and zinc) were present at specific concentrations, the result was toxicity (Fig. 5).

We believe biomonitoring to be a cost-effective approach for discovering and understanding the causes of water quality impairments. The data gathered at both RICH and UPDE were multi-year research efforts designed to develop and test procedures under field conditions. After the procedures were established and used in SACN, EVER, and WICR, we approximated

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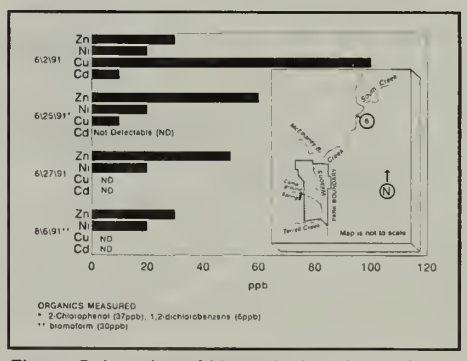

Figure 5. *Location of biomonitoring site 6 with respect to Wilson's Creek National Battefield Park, Missouri. In previous studies, site 6 was chronically toxic to daphnids. By using Toxicity Identification Evaluation (TIE) procedures, combinations of zinc (Zn), nickel (Ni), and copper (Cu) were judged to be responsible for the toxicity.*

Water Rights and the National Park Service Part II: The Federal Reserved Water Rights Doctrine

By Owen Williams

Editor's Note: *This is the second of two articles by the Chief, Water Rights Branch, NPS Water Resources Division in Fort Collins, CO. The first appeared on p. 30 of* ***Park Science****, Vol. 12 No. 3.*

Origin

The tension between the Doctrine of Prior Appropriation and federal "Reservations" culminated in a court case that changed the face of western water law. The Fort Belknap Indian Reservation in Montana was created in 1888 to change the "habits" of "... a nomadic and uncivilized people" into those of "... a pastoral and civilized people." In 1898, efforts to develop irrigated agriculture on the reservation immediately ran afoul of the Doctrine of Prior Appropriation because water in the Milk River had been appropriated prior to 1898 by other irrigators. Thus, under state law, the Indian appropriation would be junior, and unfulfilled.

In 1908, the U.S. Supreme Court determined that when Congress created the Indian Reservation, by **implication** it also reserved from the unappropriated waters of the state that water necessary to achieve the intent of the reservation – namely, irrigated agriculture. This reservation of water occurred on the date of the land reservation and was senior to appropriations that occurred after that date.

This case, Winters v. United States, 207 U.S. 564, 28 S.Ct. 207,50 L.Ed. 340 (1908), created what came to be known as the Winters Doctrine or Winters Right. While the decision stood the Doctrine of Prior Appropriation on its head, it at least appeared to be limited to the unique concerns of Indian law.

Evolution

The fervent hope of westerners that the Winters Doctrine would apply only to Indians was soon dashed as the Court generalized its applicability to all "federal enclaves." Over time a series of decisions by the U.S. Supreme Court gave the doctrine substance and form. Eventually this creation of the court took on its present name and, through recent decisions, its growth finally was checked.

Some have argued that the doctrine was merely a ploy to legalize a federal "taking of property without due compensation." Others hold that the doctrine represents state law giving way to Federal Sovereignty. Whichever the case, federal reserved water rights added substantial uncertainty to what had been viewed as a fairly ordered and settled approach for using a scarce resource.

Elements of the Doctrine

As the Court has made rulings, it has "interpreted" its own creation. Subject to future additional evolution, the doctrine has the following characteristics:

- when land is set aside from the Public Domain for a specific purpose requiring water, water sufficient to accomplish that purpose is reserved from the unappropriated waters of the state;
- the priority date of the right is the date of the land reservation;
- the amount of water reserved is that **minimum** amount necessary to **prevent the defeat** of the purpose of the reservation;
- the reservation of water is only for the **primary** purpose of the reservation, no other;
- the right is not constrained by state law (for example, it is not lost due to non-use, and purposes need not be recognized as beneficial by the state); and
- the right is to meet present and **future** neesd.

How the Doctrines Relate to the NPS

NPS Reservations

As noted earlier, the NPS organic act defines its "reservations" and their purposes. It would appear that the NPS's position would be pretty secure and therefore eliminate any concerns about water rights. The reality of the situation however is a bit more complicated. First, the reserved rights doctrine may not apply to all NPS areas because some have not come from the Public Domain, but rather from state or private ownership.

Furthermore, many NPS reservations are of fairly recent vintage. Thus, while the doctrine might apply, the priority date may be so junior as to be ineffective in providing protection against impact from other water users.

The NPS Case

Additional complications are found in the definition of NPS reservation purposes. While the NPS organic act links Parks, Monuments and other units under the same umbrella of purposes, some State Courts have made a distinction between Parks and Monuments. Specifically, the courts have looked to the enabling legislation or Proclamations for Monuments to find purposes rather than relying upon the broad language quoted above. Contrary to expectation, looking at the authorities for setting aside specific sites does not necessarily produce a better definition of purposes.

The determination of the minimum amount of the right is a further complication, especially in view of the vague purposes often cited in typical enabling legislation or Proclamations. As a general principle, the courts are reluctant to accept the proposition that a Park or a Monument has a reserved right entitlement to all water not appropriated at the time of the reservation's creation, including natural stream flow. This should not be surprising considering the potential for impacts to long standing state water rights. Senior appropriators could suddenly find themselves to be juniors because of the federal reserved right.

Limitations of the Doctrine

The only way to quantify and secure recognition of a federal reserved water right is by participating in a basin-wide general adjudication of water rights. This was made possible in 1952 by passage of the McCarran Amendment (66 Stat. 560, 43 U.S.C.A. S 666) which granted a limited waiver of Sovereign Immunity to allow suit of the United States for the purpose of adjudicating water rights. Thus it is that, to secure its rights to water in Parks and Monuments, the NPS must develop evidence designed to convince the court that (1) the U.S. is **entitled** to water (water necessary for the purpose of the reservation), and (2) the amount claimed is the **minimum amount** necessary to prevent **defeat** of the reservation purpose.

Generally, when the NPS enters State Court, often a less than sympathetic arena, it must be prepared to bear the burden of proof and demonstrate with a preponderance of evidence that its claim to water for each and all reservation purposes is valid and the minimum amount necessary for both the present and the future. When the court has ruled and, if appropriate, all appeals have been exhausted, the NPS must "live" with the determination. If quantities granted prove inadequate, the only recourse is new appropriation or acquisition of existing rights under state law.

What the NPS Faces Now and in the Future

Drought and municipal growth are two of the many water related challenges facing the NPS. Water shortage coupled with increased demand result in increased pressure to dam rivers and pump aquifers. When these things occur near NPS units, it is very likely that NPS resources sooner or later will suffer. Surprisingly, perhaps, one line of defense lies in water rights. In certain instances the NPS can assert its water rights seniority as basis for protection from injury by junior appropriators. However this very likely will result in litigation, even adjudication, requiring substantial commitments in time and money by all water users, especially the NPS.

As municipal and other kinds of development proceed, most western states feel a pressing need to eliminate the uncertainty attendant to un-adjudicated, and therefore un-quantified, federal reserved water rights. As a result, the states have by and large com-

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Biomonitoring Techniques

Continued from page 7

the average cost of each of the studies (12 sampling sites tested over 7 sampling days) to be only $3,000 for 3 weeks of effort. This is a modest amount compared to only one priority polutant (chemical by chemical) analysis (one sampling site tested one time, including both organic and inorganic compounds), which can cost between $1,500 and $2,000.

Water and its accompanying aquatic communities are critical to all forms of life. We believe the data gathered from our pilot programs indicate that biomonitoring can directly assess the health of aquatic and terrestrial life. Biomonitoring is needed to ensure these aquatic resources for various interests if only for the aesthetic value of a spectacular waterfall. Increasing human populations and expanding land-use needs require society to research and develop new ways of understanding and detecting the subtle or perhaps not-so-subtle changes in water quality in our parks from *outside* sources. Biomonitoring, because it has proven to be objective as a way to target and prioritize suspected and known problem areas, in conjunction with TIE to identify specific toxicants, is worth pursuing as a valuable, cost effective component of monitoring programs in our national parks.

Nimmo is an aquatic toxicologist and Willox is an associate, both with the NPS Water Quality Division in Fort Collins, CO; Karish is Chief Scientist of the NPS Mid-Atlantic Region; Bestgen, Steidl-Pulley, Craig, and Castle all were graduate students at CO State U at the time of this study.

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Hemlock Woolly Adelgid Threatens Eastern Hemlock in Shenandoah National Park

By J. Keith Watson, Entomologist

In the winter of 1988-1989, Shenandoah National Park (SNP) personnel observed many dead Eastern hemlock, *Tsuga canadensis* (L.) Carriere, in Thornton and Frazier Hollows of the North District. Later investigations conducted in the winter of 1990 detected many defoliated hemlocks while many others had partial foliage loss and exhibited chlorosis. Several dozens of trees in both hollows were affected to varying degrees and many trees estimated to be approximately 200 years old were dead. Close examination of the foliage revealed the presence of woolly masses at the base of the needles and twigs (Fig. 1). Each woolly mass enclosed a small soft-bodied rounded aphid-like insect suspected to be, and later identified as, the hemlock woolly adelgid, *Adelges tsugae* (Annand)(hereafter referred to as HWA).

Entomologists believe this species was introduced from eastern Asia where they have found endemic, innocuous populations of this adelgid infesting Asian hemlock species in Formosa and Japan (Takahashi 1937, McClure 1987). This insect was first reported by P.N. Annand (1928) to infest *T. heterophylla* Sargent in the Pacific Northwest of the United States. The first detection in the East was recorded from Richmond, VA in 1953 (Anhold 1990), but the exact time of the adelgids introduction into the United States remains unknown. From these suspected entry points in the United States, the range of the insect has gradually spread and in many parts of its range has caused extensive mortality of both ornamental and forest hemlocks (McClure 1987). Range extension has occurred through diverse mechanisms and McClure (1990) provided data that showed wind, birds, deer, and human activity were primary factors in HWA dispersal.

Figure 1. *Egg masses produced by overwintering adults (Used by permission of Mark McClure).*

The HWA is a sap-sucking insect of the Order Homoptera, family Adelgidae, closely related to aphids, whiteflies, and scales. Adelgids are typically a two host species, with spruce (*Picea* spp.) species being the primary hosts. However, no native *Picea* have been shown to support the HWA. Twelve *Picea* spp. were tested (six native and six non-native) by McClure (1989) for adelgid suitability and none were able to sustain reproductive populations. The complex life cycle of the HWA makes management difficult, but allows several opportunities to direct management tactics. Life history of the HWA can be obtained from McClure (1989) and is summarized in Figure 2.

The adelgid extracts fluids from the tissues of the inner bark or phloem by inserting its stylet-like mouthparts through the outer bark of small twigs and branches. Damage to the host occurs as a result of stress induced when heavy infestations withdraw large amounts of life sustaining fluids from the tree. Additionally, some scientists believe that a toxic saliva is injected into the tree during feeding that disrupts plant growth hormones and modifies vascular tissues in the tree (Puritch and Petty 1971). However, this mechanism has not been documented with the HWA. Still, the trees lose vigor and become susceptible to additional and often more damaging stresses, especially drought, hemlock borer (*Melanophila fulvoguttata* Harris; Coleoptera: Buprestidae), and Armillaria root rot, *Armillaria mellea* (Vahl ex Fr.) Karst.

Dr. Mark McClure, HWA authority at the Connecticut Agricultural Experiment Station, believes that heavy infestations alone can cause hemlock mortality. He also reported on the stand and tree condition of forest hemlocks in Connecticut and discovered that when healthy vigorously growing uninfested trees became infested with HWA, they declined gradually and all were dead within four years (McClure 1991). Heavy HWA populations along with other stress factors could contribute to the death of infested hemlocks in SNP.

In SNP, the HWA has been found in all districts, elevations, and aspects in 88 percent (n = 49) of the surveyed hemlock stands. Mortality has become widespread throughout the park and little can be done to prevent the continued spread and impact of the HWA. Data collected in February 1992 from Frazier Hollow indicated a 100 percent decline in the number of hemlock crowns that received a healthy rating (Class 1) in July 1990. Furthermore, the number of hemlocks with lower crown ratings (Class 2 and 3) increased 178 and 1400 percent respectively. The number of adelgid related deaths (Class 4) increased 100 percent (Fig. 3). Although this evaluation was based on a small sample size, the condition of the hemlock stands in the park is similar to Frazier Hollow. Data to evaluate stand condition and mortality rates are presently being collected parkwide. Presently, about 10% of the hemlocks in Thornton and Frazier Hollows are dead due to stresses associated with HWA. Considering the degree of infestation and additional stresses in SNP, a large number of Eastern hemlocks could be lost. If the prognosis is severe as McClure hypothesizes all hemlocks may be in jeopardy of being lost.

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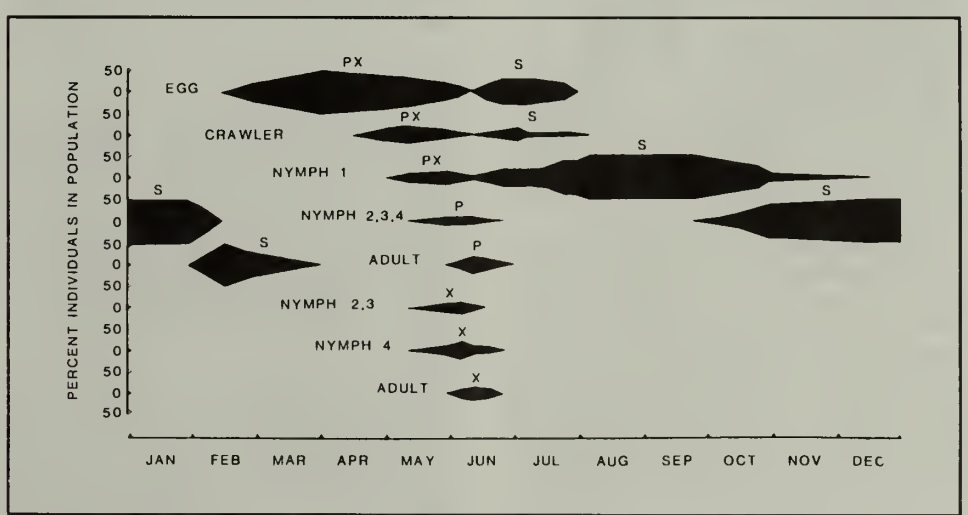

Figure 2. *Seasonal life cycle of the HWA. S = wingless overwintering generation; P = wingless forms of spring generation; X = winged migratory forms of spring generation (Used by permission of Mark McClure).*

Water Rights

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mitted to adjudicating all water rights by the close of this century. Preparing for the court battles that inevitably await will require herculean efforts by the NPS and other federal agencies.

Conclusion

The legal doctrine that governs most water use in the west conflicts with the "fundamental purpose" of the NPS. This doctrine arose, in the absence of federal guidance, to meet the needs of commerce in a semi-arid setting at a time of rapid and almost chaotic development. It served its intended purpose well, but it did not provide for the unanticipated needs of a growing and increasingly sophisticated nation. The requirements of legislation and Proclamation created conflicts that culminated in a retrofit of the doctrine using Court-created "implied rights."

The NPS employs both the Federal Reserved Water Rights Doctrine and the Doctrine of Prior Appropriation to accomplish its mission. The process of securing and protecting water rights is demanding, requiring in-depth scientific investigations and complex legal argument. However, even thought the investment to protect water rights may be high, the cost of not protecting them likely would be higher. This becomes ever more apparent as water development and municipal growth place increasing demands upon the same water sources as are relied upon by the fragile ecosystems of Parks, Monuments, and other NPS units.

The opinions expressed are those of the author and do not necessarily reflect those of the Department of the Interior or the National Park Service.

Wooly Adelgid Threatens Shenandoah Hemlock

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In SNP, the hemlock mortality associated with HWA was apparently initiated by drought induced stresses during 1986 -1988. The combined stresses of drought and HWA infestation attracted the hemlock borer, a cambium feeding beetle, which girdled and ultimately killed many of the hemlocks. Evidence of secondary beetle invasion was indicated by the presence of emergence holes and the outer bark being flaked from the tree by woodpeckers probing for borer larvae, revealing the deep rust color of the inner bark. Hemlock mortality caused by the secondary invasion of the hemlock borer has been a well documented phenomena (MacAloney 1967). However, several dead hemlocks in SNP did not show evidence of attack by the hemlock borer, suggesting death occurred from drought and adelgid infestation, and possibly Armillaria root rot. Additional stresses from gypsy moth defoliation and acid deposition may have contributed to the hemlock decline.

The potential impact of hemlock decline and mortality on park resources has resource specialists concerned. Obviously, natural resource components and biotic associations in hemlock ecosystems will be greatly affected. The adelgid has been observed in two high resource value areas in the SNP. One of these is the Limberlost, a 100 acre natural area that contains many virgin Eastern hemlocks saved from the logging industry by George Freeman Pollock. Some trees in this stand are estimated to be near 400 years old. The other unique area where hemlock decline is evident is Camp Hoover, a former retreat for government officials, and a valuable cultural and natural area. President Herbert Hoover established this fishing camp on the Rapidan River and later donated the property to the SNP.

Effects of Control Agents

Though a significant threat to the Eastern hemlock forest exists, it is doubtful that HWA management in a forested ecosystem would be successful although it could be possible in isolated "urbanized" settings in developed zones. Selected individual trees must be saturated with suppression agents from ground based equipment to ensure a high percentage of adelgids are contacted by the treatment. This quickly becomes very expensive, labor intensive, and time consuming.

"Safe" control agents could be used with this method, but they are economically unfeasible and environmentally untested to be effective in long term adelgid management. Injection of pesticides into the cambium where translocation of the pesticide would reach the adelgids is another possibility. Other traditional chemicals proven effective for adelgid control exhibit wide spectrum toxicity to other "non-target" organisms and are unacceptable for use in national park ecosystems. Natural parasitoid and predator complexes are poorly known and their potential as control agents is uncertain.

Programs to monitor populations of the adelgid in SNP and elsewhere should be developed to obtain information on the impacts of this potentially damaging insect. Monitoring is extremely important because populations of this insect can build rapidly on hemlock due to 1) parthenogenesis - the female's ability to produce offspring without the existence of the male, 2) the adaptation of two successful reproducing generations per year, 3) few significant natural enemies, and 4) other prevalent stresses in the SNP ecosystem.

Monitoring Plans

Monitoring the HWA can be incorporated into the current Inventory and Monitoring System established at SNP with only minor modifications to the existing hemlock component protocols. At present, existing plots have been surveyed and 80 percent have HWA infestations. These plots will be monitored for adelgid impacts as well as the standard measurements detailed in the Long-Term Ecological Monitoring System LTEMS manual (Smith and Torbert 1990). Additionally, plots will be established, inventoried, and monitored in uninfested hemlock stands. Data collection will allow resource specialists to detect initial invasion and monitor the spread and effects of the HWA in hemlock stands throughout SNP.

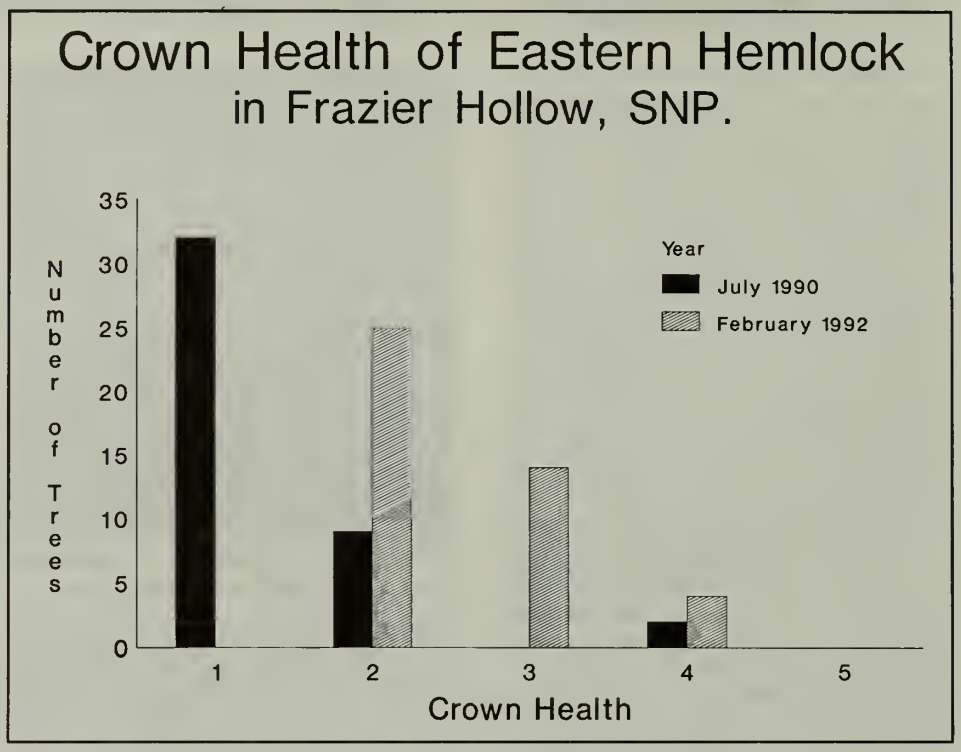

Figure 3. Crown Health of Eastern Hemlock in Frazier Hollow, SNP.

Other Affected Areas

Any NPS units in the eastern United States with a hemlock forest component could potentially be affected by infestations of the HWA. Large stands exist in both the Great Smoky Mountains NP (GRSM), Shenandoah NP, Catoctin Mountain Park (CMP), and Delaware Water Gap National Recreation Area (DEWA). No infestations have been detected in the GRSM (Langdon, personal communication) but many virgin hemlock stands remain that provide both high value aesthetic and ecological resources. Hemlocks forests in DEWA provide one of the area's most valuable visitor use resources and recently have become infested. The infestation is rapidly increasing, causing widespread defoliation that represents a tremendous potential for significant hemlock mortality in the future (Millington, personal communication). Blue Ridge Parkway personnel have reported the HWA at various locations from the northern sections south to Milepost 150 (Teague, personal communication).

Other infestations have been reported in the National Capitol Region where some pesticide treatment has occurred. No other infestations have been reported, but surveys should be conducted to determine the presence of this non-native species in our federal lands, particularly the National Park System, where a major goal is the preservation of natural ecosystems and processes. If infestations are suspected, samples should be collected and sent to local universities or specialists to confirm identifications. Infestations should be reported to the Regional USDA Forest Service Pest Management Office.

The adelgid has been in SNP for many years, and extensive mortality can be expected, especially when associated with other stress factors. The outlook for the hemlock stands in the park remains unclear due to the uncertainty that surrounds the adelgids true potential as a contributor to hemlock mortality. What is certain is that the HWA will remain in Shenandoah as long as the hemlocks remain. When the hemlocks become sparse, the complex community of organisms associated with this forest system also change. Extensive efforts should be initiated to develop better management strategies and an understanding of HWA and its role in forest dynamics. It is imperative that efforts be conducted to inventory and monitor our hemlock forests so better assessments can be made toward determining the potential this species has on an extremely valuable natural resource community.

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Eastern Hemlock: The Next American Chestnut?

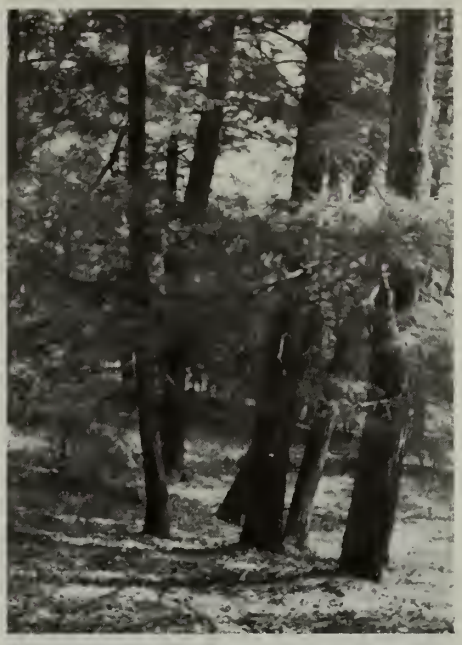
By David Hayes

Most of us are too young to have any memory of the American chestnut (*Castanea dentata*) as a significant component of eastern forests. Once comprising 25 percent of total timber volume, it is now relegated to persistent stump sprouts that survive for a few years before succumbing to the cause of its decline, the introduced chestnut blight fungus (*Endothia parasitica*). A similar fate may await the eastern hemlock (*Tsuga canadensis*) and Carolina hemlock (*Tsuga caroliniana*) at the hands of yet another Asian invader: the **hemlock wooly adelgid**.

Hemlock wooly adelgid (*Adelges tsugae*) has no known predators or parasites. Within one to four years, most untreated hemlocks are dead. Highly desiccated, the dead trees break apart very rapidly; whole stands have been levelled in Connecticut in just a few years. Since the moisture content of hemlocks that have succumbed to the adelgid is greatly reduced, fire danger is intensified.

The most troubling aspect of this situation is the potential for large-scale loss of hemlocks from eastern forests. In southeastern New York and most of Connecticut this has already begun. *Tsuga canadensis* is often found in great numbers here, sometimes at canopy densities of 80 percent or higher. It is extremely shade-tolerant, and can persist as an understory species for decades; its longevity also allows it to reach the overstory when conditions permit. The shading it provides results in reduced sunlight transmission through the canopy, hence lower temperatures in streams, wetlands, and on the forest floor. It provides roosting sites for woodland birds, including barred owl (*Strix varia*), great horned owl (*Bubo virginianus*), and ruffed grouse (*Bonasa umbellus*).

Since there is no apparent ecological replacement for hemlock, its loss on a large scale will be significant. The cool, moist microhabitats it provides will be greatly reduced. The simultaneous loss of hemlocks growing in dense stands on steep ravine slopes will undoubtedly cause erosion. There is no practical way to control *A. tsugae* in areas not accessible to large hydraulic spray equipment; aerial applications are ineffective since 100 percent foliar coverage cannot be attained.



***Most of the trees** in this hemlock-dominated forest at Vanderbilt Mansion NHS are in their first year of infestation. (Photo by D. Hayes)*

The northern front of the infestation is moving through New York State and New England. The Roosevelt-Vanderbilt National Historic Sites are near the current northern frontier of the adelgid's spread. *A. tsugae* has invaded the landscaped area at Vanderbilt Mansion NHS, and is being treated with horticultural oil. Landscaped areas in all units of the park, which total 48 ha (119 ac), will be rigorously monitored, and all infested trees will be treated. In the natural forest zones of the park (170 ha = 420 ac), permanent monitoring stations are being established to track changes in species composition of plants, invertebrates, herpetofauna, and birds. Streams and wetlands will also be monitored for changes in physical and chemical characteristics.

While these efforts will add to our understanding of the effects of hemlock population decline or local extirpation, they will be poor consolation for the loss of such an important species from forest ecosystems in the eastern U.S..

* * *

Horticultural and resource management personnel from Roosevelt-Vanderbilt NHS attended an April 29, 1992 meeting at Mystery Point in Garrison NY, where site managers, foresters, landscapers, and researchers discussed strategies for dealing with *A. tsugae*. Mystery Point, a 19th Century estate now owned by the environmental organization Scenic Hudson, provided a dramatic setting, with dead and dying eastern hemlocks covering much of the estate's 136 acres.

Mark McClure of the Connecticut Agricultural Experiment Station briefed attendees on adelgid identification, life cycle, and control techniques. Dr. McClure left soon after an a two-month research trip to Japan, seeking natural predators of A. tsugae for potential introduction in the U.S.

Hayes is Natural Resource Specialist at Roosevelt-Vanderbilt NHS.

Wooly Adelgid

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hemlock woolly adelgid, Adelges tsugae *(Homoptera: Adelgidae). Ann. Entomol. Soc. Am. 82:50-54.*

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book review

WILDLIFE RESEARCH AND MANAGEMENT IN THE NATIONAL PARKS, R. Gerald Wright, 1992. University of Illinois Press, Urbana and Chicago, 224 pages. Cloth, $32.50. Notes, appendix, figures, tables, bibliography, and index.

Gerry Wright has presented a much needed and long overdue account of the evolution and present day treatment of wildlife research and management in the National Park Service. From the introduction to its conclusion, relatively unusual facts and little known accounts of past actions and deeds are presented. Unpublished literature and incidents that may have long escaped attention, have been forgotten, or have been buried, are here made available. Memories and notes of those managers, biologists, and scientists who have left the Service in body but not in mind are now brought into the light. As Paul Harvey says, "And now, the rest of the story."

Gerry's unique perspective is not only informational and thought provoking, it reflects his personal concerns and commitment for wildlife management and research in the Park Service. While some may argue that he is not critical enough, others will maintain that the book is an expression of sour grapes. It is neither. It is a well written and researched review of the history and evolution of wildlife management and research in the NPS.

The book is an important and valuable contribution to an understanding of the evaluation of NPS wildlife research and management activities ... a must read for everyone who is involved, interested, or concerned with wildlife in our national parks. It is not only for those within the Service, but for those in conservation at the local, state, and federal levels and in the private sector.

While the book is not perfect, the errors are few, the generalizations, data interpretation, and interpretation of past and present literature are neither slanted nor biased pro or con. The availability and use of more current data and information in a number of the tables and figures would greatly have enhanced the book. Read it; you'll enjoy it.

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notes from abroad

By Janet Edwards
Former Natural Resource Specialist
Pacific Northwest Region

In 1909 Sweden passed legislation establishing its first nine national parks. They were intended to be undisturbed natural settings managed in similar fashion to USA national parks. Despite the fact that both park agencies deem one of their fundamental purposes as scientific, science in the parks means something quite different in Sweden than it does in the United States.

Abisko NP, situated adjacent to Lake Torne, is an international biosphere reserve. Here, within a nature reserve adjacent to the park, lies Abisko Research Station, established in 1903. Since 1935 it has been administered by the Royal Swedish Academy of Sciences. Hosting often as many as 80 scientists in the summer, it has become an internationally known Arctic research station, where investigations from many disciplines – especially bioscience and geoscience – are conducted. The commonest research topics are plant ecology and meteorology (Sonesson 1991). Equipped with workrooms, geo- and radio-laboratories, computer and drawing rooms, and greenhouse facilities, the station is open to visiting scientists (Royal Swedish Academy of Sciences 1985).

Abisko is only one of the many sites where environmental research is conducted in Sweden. Research within parks has not for the most part been driven by park administrators. Decisions about types and scope of research within parks have been generated by the investigating official, often from one of the Swedish universities, sometimes even from abroad.

By 1990 the Swedish Environmental Protection Board, under whose jurisdiction the national parks fall, realized the need for a systematic inquiry into the types of research that have been conducted in the parks. All published materials now are being collected and accounted for, their scientific integrity evaluated, and research methods assessed. Results will be noted and a corresponding data base will be created. In addition, both a geomorphological and a vegetation map are desired for each park. The "Documentation of Sweden's national parks," a report proposed by the national park administrative staff, will include baseline information on geology, flora, fauna, and other resources within specific parks (Bergqvist, 1990).

The 1983 (and most recent) literature collection for studies done within the parks has several hundred project entries including topics in geology, glaciology, meterology, botany, zoology, limnology, ornithology, and entomology (Naturvardverket 1983). Most of the projects are pure science based, as opposed to applied science or resource management oriented. Much of the research has provided important baseline data on park resources. The limitations of current and past research rest with the absence of projects that define resource problems and their proposed solution.

In an attempt to integrate and direct science in the parks, a research plan for the parks is being funded by the Environmental Protection Board. Written by university staff, this plan will describe proposed research needed to provide further information on park resources.

Despite the Environmental Board's interest in systematizing research in parks, most environmental work done in Sweden is not earmarked for park sites. To understand why this is so, it is important to note three conditions that exist in Sweden and reduce the need for establishing large research project within parks.

First, Sweden has a long tradition of "every man's right" when it comes to land (Naturvardsverket 1982). Because of this, research sites can be set up as easily on private and company lands as on government owned lands.

Secondly, Sweden has a population of only about 8.3 million. For a country of 450,000 square km, about the size of California, Sweden is rather sparsely populated. In the far north, populations can be as low as 2 to 3 persons per square km. When seeking a naturally vegetated landscape where sites could be stationed, a researcher has a wide range of choices.

A third consideration is that Sweden's goals for nature protection include maintenance of landscapes sculptured by human use. Farmlands, pasture lands, burial mounds, and Laplander reindeer grazing traditions are as important as wilderness where protection is concerned. Human impacts on landscape are not always considered a negative attribute. Although uses are limited and often regulated, the general focus of nature research is not on monitoring normal and anticipated human impacts to the land. The major threat to natural resources generally is stated to be the forestry and agricultural industries. Where these activities prevail, there is direct and significant impact on biotypes (Larsson 1990, p. 8).

Although there currently is no integrated research program for parks, a large and cohesive environmental research effort has been pulsing in Sweden since 1967. At that time, one of the most comprehensive environmental programs, monitoring and assessing the effects of acid rain deposition, began. The national government reacted immediately to scientific findings about adverse impacts of acid rain. Rather than waiting for large funding or national guidelines, monitoring began shortly after the problem was first discovered in the late 1960s.

Swedish scientists are particularly interested in the critical load concept, hoping to discover how much pollution the environment can tolerate. With 80 to 90 percent of acid deposition coming from other countries, the need to investigate this building problem has pushed research on it to the fore. Liming of lakes is a common procedure, used to rehabilitate the affected aquatic environment. However, liming does not take place in national parks, since national standards require that parks be kept in their natural condition and maintained as baseline reference areas (Thornelof 1991). Thus the parks suffer greater cumulative impacts.

Global warming studies also are important in Sweden, although funded to a tune of only about one sixth the amount of the acid rain program. Sweden relies a great deal on data supplied by other countries. Some modeling work has been done on the probable species composition of Swedish forests after increased global warming. Changes in the patterns of mountain birch and incidents of insect defoliation also have been investigated. Cooperative research for global warming is ongoing, even on Svalbard Island north of Norway.

Outstanding wetlands, botanical resources, wildlife, and geological formations are as important as parks to Sweden's concept of nature protection. Together the parks and reserves protect approximately 5 percent of Sweden's land base. The current parks comprise about 627,000 ha as compared with nearly 2 million ha of nature properties.

The National Environmental Protection Board has primary jurisdiction over environmental programs throughout the country, whether within parks, reserves, or other public or privately owned lands. The Board provides funds for such programs, then distributes them to local county boards (24 of them) for local research and monitoring. Requests can be made by the local county boards for establishment of new nature reserves and subsequent funding for inventory and management. Furthermore, science stipendiums are awarded yearly by the National Board for research as well as applied projects that enhance nature conservation efforts.

This year, management of the Swedish national parks was transferred from the National Environmental Protection Board to local county environmental agencies. The local offices are staffed with science professionals. Together they handle a variety of resource management projects for parks, reserves, bird sanctuaries, and other protected natural sites. County personnel grant and regulate permits for research on these sites. In addition, these environmental offices work with landowners as well as with the forestry agency, writing up agreements, discussing use restrictions, and designing rehab projects.

The holistic approach to science related to nature conservation in Sweden functions well for a country of its size and population. Visitor numbers are relatively low in parks, which means that most internal resource problems are incurred through permitted land uses. External threats, however, have been measured and are of immediate concern to Swedish environmental managers. To pinpoint impacts, baseline data gathered over an extended time, are critical to Sweden's approach to science. International conferences, agreements, and shared research also are important ingredients used to address protection of natural resources.

Edwards has been living in Sweden and learning about its natural parks and reserves for the past two years.

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information crossfile

Two NPS scientists, D.J. Shaver of Padre Island National Seashore and M.R. Fletcher of the CPSU at the University of New Mexico, appear in the Letters column of ***Science*** for July 24, 1992, with a spirited reply to Gary Taubes' article about Kemp's ridley sea turtle conservation (Research News, May 1, p. 614, ***Science***). After correcting what Shaver and Fletcher term "ambiguous, misleading, or incorrect" statements regarding NPS activities in the Taubes article ("A dubious battle to save the Kemp's ridley sea turtle"), the authors note that "public awareness about the plight of sea turtles has increased as a result of NPS efforts." Further, they point out that "some of the biological information collected by the NPS was the first of its kind for the species and has been used to assist with efforts in Rancho Nuevo, Mexico" (where the turtles' eggs were collected each summer from 1978 to 1988 and transported to Padre Island National Seashore in an international multi-agency effort to establish a secondary breeding colony through imprinting.)

This saga has received ongoing coverage in ***Park Science***, most recently in this issue (see pp. 26-27). The Shaver/Fletcher closes with this paragraph:

"The NPS is now focusing conservation efforts for this species on attempts to locate and protect nesting females (wild and headstarted) and stranded hatchlings. Staff at PAIS (Padre Island) are conducting extensive beach patrol and public education efforts, both of which have been given high priority in the recently completed Kemp's Ridley Sea Turtle Recovery Plan. As directed by the recovery plan, NPS mandates, and the Engangered Species Act, these efforts will continue for the foreseeable future."

* * *

"Keeping aliens out of paradise," by Anna Maria Gillis in the July/August issue of ***BioScience*** (pp 482-485), describes the host of educational, research, and enforcement programs developed by the Hawaii Dept. of Agriculture, federal agencies, and numerous environmental groups in the effort to limit alien species' impacts on the native flora and fauna.

Gillis quotes Alan Holt, one of the authors of "The Alien Pest Species Invasion in Hawaii: Background Study and Recommendations for Interagency Planning" (prepared by The Nature Conservancy of Hawaii and the Natural Resources Defense Council) as suggesting that the rate of new species invasions is "thousands of times faster than it was in prehuman times, when one new colonist was estimated to arrive on the islands approximately every 10,00 years." Many scientists now say, writes Gillis, "that Hawaii harbors more aliens than natives." She discusses biocontrol and notes the objections of British Museum entomologist Frank Howarth. He attributes the decline of numerous Hawaiian species – from moths to damselflies to snails – partially to the introduction of biocontrol agents. "In some cases, the agents become pests themselves," writes Gillis. The real focus, says Howarth, should be on cutting the influx. "Once we close the door on new species introductions, then we can figure out how to control what we already have."

* * *

A new department, The Professional Biologist, began appearing in the July/August 1992 issue of ***BioScience***. The premier subject matter for this department was sabbaticals – a time "to redefine objectives, reflect, evaluate your professional performance, and be creative ... a time during which you can consider the important spiritual and intellectual goals that higher educaton must pursue for their own sake ..." and a time to "interact with colleagues in different educational and geographical environments and to experience another culture."

The Professional Biologist's verdict is contained in the first column's headline: "A Sabbatical? Do It!"

* * *

Farmers soon may be producing *plastic* from their potato and sugar-beet crops according to word from Michigan State and James Madison University scientists in ***Science***. "For the first time, a plant has been genetically engineered to make something other than a protein – something no other plant has ever made before," according to Christopher Somerville of Michigan State's Plant Research Lab.

The plastic, called polyhydroxybutyrate, is being grown in an experimental plant. PHB, a polyester, could be used as a liner for disposable diapers and for containers. A British company is producing it from bacteria to make shampoo bottles, but this is the first successful attempt to get plants to grow plastic. PHB is similar to polypropyolene, a plastic used for molded parts, electrical insulation, packaging, and fibers for clothing; however, PHB is biodegradable and is chemically similar to starch. Both PHB and starch can serve as a way for plants to store carbon.

For 20 years scientists have known about a family of polymers accumulated as storage products in many species of bacteria and blue-green algae. The three genes necessary for one of these bacteria, *Alcaligenes eutrophus*, to make PHB were identified and cloned in 1987 by Douglas Dennis at James Madison U in Harrisonburg, VA. One of the genes also is found in higher plants, including *Arabidopsis thaliana*, a small, quick-growing mustard plant with a very simple genetic structure.

Somerville and colleagues inserted the two key genes from *Alcaligenes eutrophus* into *Arabidopsis thaliana*. They established a new line of Arabidopsis plants with one gene and a new line with the other gene. Then they cross-fertilized the two lines to create a hybrid with both genes. This hybrid then began making PHB in small amounts – in its leaves, stems, and roots.

Somerville said that PHB production is a crucial first step in getting plants to grow a whole family of biodegradable plastics from polymers similar to PHB.

* * *

A less deadly ("hypovirulent") strain of chestnut blight has been found to neutralize the killer strains that have felled the mighty American chestnut trees, once dominant in eastern North America. ***Science News***, in its Aug. 8, 1992 issue, reports on use of the less deadly strain, which causes only superficial, temporary sores on the bark, according to Donald L. Nuss of the Roche Institute of Molecular Biology in Nutley, NJ.

A viral infection reduces this fungal strain's ability to destroy the chestnut tree, according to Nuss and a colleague. Their report in the Aug. 7 ***Science*** describes how making DNA that encodes the virus' RNA, may enable them to harness this virus—or an improved version of it—for controlling chestnut blight. The transformed fungus that results from the transplanting of the virus causes small cankers to develop on a chestnut stem rather than large, rapidly expanding ones, says Nuss.

* * *

J. Boone Kauffman, a fire ecologist in the rangeland resources department at Oregon State University, reports in the Winter 1990 issue of OSU's ***Oregon Agricultural Progress*** on his ongoing study of the impact of fire in the rain forests of South America. He describes an ecosystem that is "unraveling" and irrevocably changing.

"Ashes in the Amazon," by Carol Savonen, describes Kauffman's assessment of the situation in Brazil as a matter of more than mere fire ecology. "It is obvious," Kauffman notes, "that rampant deforestation is not a biological problem. It's merely a reflection of social problems with multiple causes."

These multiple causes also produce multiple and far-reaching effects. To quote the article: "An intact rain forest creates its own climate—scientists estimate about one half of all rainfall originates from the moisture given off by the forest itself. When large tracts of land are deforested, local and overall climatic patterns may change. Once the forest is gone, drought may occur, intensifying the probability of fire and decreasing the probability the forest will ever return."

* * *

As if to underscore the possibilities raised in the Boone Kauffman article (see above) the following item appeared in the August 17, 1992 ***Earthweek: A Diary of the Planet***, a feature carried in many U.S. newspapers.

"Searing heat and a severe drought have ravaged 78 counties in southern and eastern parts of China's Sichuan province since late June. The official Xinhua News Agency reported that the dry spell has devastated 5.2 million acres of crops and caused a shortage of drinking water for more than 9 million people and an equal number of livestock. An extended drought is causing similar problems in Hubei and Anhi provinces.

"Some of the hottest weather since 1775 has been baking central Europe, worsening the summer drought

> "Beginning with the environmental era, the dignity and nobility of the national parks, once seen largely in terms of majestic landscapes, came also to be measured in the precise, objective terms of science. And it has become apparent that, due to human influences from inside and outside park boundaries, the parks' natural resources have increasingly undergone ecological degradation, slipping father from any semblance of pristine conditions ...
>
> "Despite the Service's increasing efforts to address these threats, there has been only limited progress in restoring anything like pristine natural conditions. Thus, while the parks continue to be tremendously popular with the American public, the goal of leaving the parks indeed ecologically unimpaired seems more and more unattainable – moving farther out of reach like a distant, receding star."
>
> From *"The Roots of National Park Management: Evolving Perceptions of the Park Service's mandate,"* by Richard West Sellars, historian with the NPS, Santa Fe, NM, in ***Journal of Forestry***, Vol. 90, No. 1, pp 16-19.

regional highlights

Pacific Northwest

"Crater Lake NP: Still Beautiful at 90" is the title of the scientific symposium held at the park in May of this year, at which many scientists, who have been studying Crater Lake since a 1982 act of Congress boosted research efforts, reported on their work.

"It's becoming increasingly clear that Crater Lake is a dynamic system (that) changes and fluctuates over time," said Gary Larson, associate professor of forest resources at Oregon State University and leader of the NPS/CPSU there. "Some of these changes, including such things as the water level, clarity, and production of plant and animal life, appear to be cyclical," he said. "There are seasonal, annual, and long term fluctuations, but we're not certain of the exact nature of these cycles ... It's safe to say that at this point research on Crater Lake is still gearing up, not down."

A new role for the lake emerged – as "the world's largest rain gauge." One of the newest projects is using the lake as a barometer of global climate change and learning what effects climate, in turn, will have on the lake, Larson said. For instance, the lake's water level dropped 16 feet during the "dust bowl" of the l930s. It later rose to levels approximating those of the last turn of the century, and in the 1980s has again dropped about 6 feet.

* * *

New faces and new places in the Region include:

Vicki Snitzler-Neek, as Resource Management Specialist at Craters of the Moon, replacing Shelley Sparhawk, who joins the Resource Management staff at Olympic NP;

Paul Gleason, to Olympic NP as Archeologist (a new position), from the Alaska Regional Office in Anchorage;

Karen Taylor-Goodrich, to a new position as Supervisory Natural/Cultural Resource Management Specialist at Coulee Dam NRA, after completing the Natural Resource Management Trainee Program;

David Elk, from Resource Management at Carlsbad Caverns to a new Resource Management Specialist position at Fort Clatsop National Memorial in Oregon;

Shirley Hoh, from Theodore Roosevelt NM to San Juan Island NHS, to fill a new Resource Management Specialist position;

Hugh McDonald, from Cincinnati Museum of Natural History where he was curator of vertebrate paleontology, to the new Paleontologist position at Hagerman Fossil Beds NM in Idaho;

Marsha Davis, from Jewel Cave NM to the Regional Office, filling the new Geologist position in the Resource Management and Protection division; and

Erv Gasser, from Richmond NBP to fill the position in the Resource Management and Protection division vacated when Steve Gibbons transferred to coordinator of the Region's National Natural Landmarks.

* * *

An item in the August 12 Regional Weekly Highlights reads as follows:

"Last Thursday afternoon a family of five in front of the Nez Perce NHP Visitor Center looked south and saw something large walking in the wheat fields on a hill about a quarter to half a mile away. They went into the visitor center to ask the ranger what it was. Park Curator Sue Buchel stepped outside the VC and confirmed there was something dark, larger than a human, walking in the fields. It disappeared while they went back in to get binoculars.

"Over the hill, another family reported seeing the creature from a distance of about 150 yards. Grover Crantz of Washington State University, who has researched Sasquatch for 20 years, traveled to the park on Friday. He has called it a good sighting. There were 13-inch footprints in the area. Supt. Frank Walker has fielded media calls from Massachusetts, Pennsylvania, New York, Wisconsin, Missouri, Indiana, Utah, Washington, California, and Alberta, Canada."

Southwest Region

A cave research program and a study of the feasibility of establishing a cave research institute have been undertaken by the Southwest Regional Office Asst. Regional Director for Planning, as directed by Public law 101-578, dated Nov. 15, 1990. The study will result in a report to Congress covering the need for an institute, its purposes, what elements the facility should include, recommended location, its cost and management.

The Division of Natural Resource Management and Science staff is assisting with the study and will incorporate the input of cave specialists from BLM, USFS, USGS, and from the private sector and several universities. The study is slated for completion by Spring 1993.

* * *

Training remains a high Regional priority. Jerry McCrea assisted Dr. Terry Cacek, the new Servicewide IPM Coordinator in presenting a 40-hour IPM course at Albright in June; the Southwest Region offered an IPM class for Africanized honeybee management in August; and in September the Region's staff joined forces with the Midwest Regional Office staff to present an IPM course for museum curators in Lawrence, KS. Personnel from the Pacific Northwest and Rocky Mountain Regions also attended.

information crossfile

in the region and causing outbreaks of unhealthful air.

"The water level of Lake Titicaca, located high in the Peruvian and Bolivian Andes, has dropped two feet this year because of drought."

* * *

zResearchers are making progress toward a vaccine to combat the tick-borne illness Lyme disease, according to John Travis's "News & Comment" department in ***Science*** (Vol. 256:1623). Travis cites the June 15 ***Proceedings of the National Academy of Sciences***, in which a team of researchers from Harvard and Yale report that mice vaccinated with a protein from the surface of the bacterium that causes Lyme disease (*Borrelia burgdorferi*), successfully fight off infection from tick bites. The bacterium, a spirochete that is transmitted to humans from its natural hosts—mice and deer—by tick bites, apparently is killed by the antibodies triggered by the vaccine. It is suggested that "it might be possible to curtail the spirochete's population severely and limit the spread of Lyme disease by vaccinating mice and deer."

* * *

Richard N. Mack of Washington State University's department of botany reviews in ***Science,*** June 19, 1992, p. 1699, a new book by R.H. Groves and F. di Castri, Eds., Cambridge University Press, 485 pages, illustrated, $125. The book, ***Biogeography of Mediterranean Invasions***,(31 chapters) includes reports on work not well known to English-speaking biologists, says Mack, but "it comes at the price of depth on any one topic." Mack deplores a missed opportunity to evaluate the "sometimes obscure literature that reports the circumstances of an immigration" but notes praiseworthy exceptions—the chapters by Kloot and Rejmanek *et al.* on invasive plants in southern Australia and California, respectively, and Blondel's "insightful chapter" on bird invasions in the Mediterranean region.

This book," Mack concludes, "will certainly provide intriguing reading for anyone who is interested in rapidly unfolding biological phenomena."

* * *

College of the Atlantic biologist Dr. Craig Greene and three COA graduates have developed a computer database that indexes all research articles written on natural resources of Acadia National Park and adjacent areas in Downeast coastal Maine. "Beause Acadia has been the focus of many naturalists' studies over the past 150 years, the natural history of Mount Desert Island may be the best known of any area of comparable size on the continent," Greene said. "But up until now, no comprehensive bibliography of this information has existed." The accumulated information will serve as a foundation for future inventorying and monitoring in the Park.

The index is organized by region, species, date, author, and other keywords, and provides an annotated summary of each of the more than 1,000 research articles that have been written on the park, some of them dating back to the 1800s.

* * *

Michael Zimmerman, a biology professor and associate dean of the College of Arts and Sciences at Oberlin in Ohio, reported in a July 1992 syndicated column on the impressive improvements in the Third World's agriculture as a result of shifting from pesticide-based to an integrated pest-management approach. Basing his column on a ***Science*** magazine report, Zimmerman cites a 10 percent increase in Indonesia's rice field harvests, plus "a huge decrease in capital outlay for chemicals, and an untold dimunution of pesticide-related illness."

The bad news came from David Pimentel, one of the world's leading agricultural experts and a biologist at Cornell University. Pimentel estimates that more than 500 species of insects now are resistant to pesticides and that the amount of crops "lost to insects has almost doubled during the last 40 years despite a more than 10-fold increase in the amount and toxicity of insecticide" use.

In addition, the Regional Technical Support Center at U/NM provided a 3-day GIS training workshop in August on the use of Environmental Planning and Programming Language (EPPL7).

* * *

Africanized honeybees are continuing their northward advance. On Aug. 3, 1992, the staff at Big Bend NP was notified that a positive Africanized honeybee identification had been made on bees collected within the park. Identification was made by a specialist at the USDA Bee Research Lab in Beltsville, MD.

The bees were collected on July 21, 1992, from a swarm trap located at Rio Grande Village. Due to genetic variability, this subspecies has a range of behavior; this particular swarm's behavior was not overly aggressive.

Big Bend NP is the second park within the Region to have a confirmed identification of this bee. Amistad NRA was the first. San Antonio Missions NHP probably will be the third, as a confirmed identification has taken place at nearby Fort Sam Houston.

Considerable emphasis will be placed on education, prevention of infestations in and around structures, and management of singular colonies and/or swarms in developed areas. Quarantine of infested counties will sharply reduce the practice of moving beehives and will require significant changes in agricultural practices in Western states, which are quite dependent on migratory beekeeping.

Southeast Region

Dr. Joseph Clark has been selected to head the NPS/CPSU at the University of Tennessee. The former assistant chief of the Arkansas Game and Fish Commission, Dr. Clark earned his PhD at the University of Arkansas (U/AR), and an MS from U/GA. He served as research coordinator for the AR Game and Fish Commission, has done extensive research on black bear ecology, and was a research technician for the Cooperative Wildlife Research Unit at the U/GA's school of forest resources.

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Dr. Caroline Rogers of Virgin Islands NP has received the Pingree School Alumni Association's award honoring the graduate who has made significant contributions to the quality of life of his or her school and community of fellow man, through extraordinary effort and dedicated service.

* * *

Dr. Stephen Shabica, formerly an Oceanographer for the Southeast Regional Office, now is a Resource Management Specialist for Cumberland Island NS. Rich Dawson, Resource Management Specialist, SERO, has transferred to the USFWS in Atlanta as a fish and wildlife biologist.

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Reports recently published in the Region include:

Claxon, P.G. and H.L. Renwick. 1987. *Bibliography of Scientific Research for Cape Hatteras NS.* CPSU, Rutgers-The State Univ. of NJ. NPS/SER/92.

Claxon, P.G. and H.L. Renwick. 1987. *History of Scientific Research for Cape Hatteras NS.* CPSU, Rutgers. NPS/SER/92.

Claxon, P.G. and H.L. Renwick. 1987. *Bibliography of Scientific Research for Cape Lookout NS.* CPSU, Rutgers. NPS/SER/92.

Claxon, P.G. and H.L. Renwick. 1987. *History of Scientific Research for Cape Lookout NS.* CPSU, Rutgers. NPS/SER/92.

Claxon, P.G. and H.L. Renwick. 1987. *Bibliography of Scientific Research for Cumberland Island NS, Vol. I.* CPSU, Rutgers. NPS/SER/92.

Claxon, P.G. and H.L. Renwick. 1987. *History of Scientific Research for Cumberland Island NS, Vol. II.* CPSU, Rutgers. NPS/SER/92.

Doren, R. and C. Doffermyre (Eds.), *South Florida Research Center 1991 Annual Reports, Vol. 1,* containing sections on the management of database, hydrology, marine, vegetation, and wildlife programs. Everglades NP, South FL Research Center, PO Box 279, Homestead, FL 33030.

Herndon, J.G. 1991. *The Hydrology of Southern Cumberland Island, GA.* Kings Bay Environ. Monitoring Program, U/GA CPSU. NPS/SER/91-04.

Schmidt, T.W. 1991. *Scientific Studies in the Coastal and Estuarine Areas of Everglades NP: An Annotated Bibliog.* Everglades NP, S. FL Research Center,. NPS/SER/91-02

Van Cleave, R.L., W.G. Beard, B. Shunamon, and J.D. Peine. 1990. *Trail Use Monitoring in Great Smoky Mountains NP: Results from 1988, 1989 and 1990.* Uplands Field Lab. NPS/SER/92-01.

Zoodsma, B.J. 1991. *Distribution and Behavioral Ecology of Manatees in Southeastern Georgia.* Kings Bay Environ. Monitoring Program, U/GA CPSU. NPS/SER/91-03.

Alaska Region

A gray wolf, tagged in Gates of the Arctic NP& Preserve with radio collar #321. recently was taken by a hunter in Fort McPherson, Northwest Terr., Canada. Alska wolf #321 was born in 1986 in the central part of the Brooks Range, AK. In 1987, the animal was tagged as part of a NRPP funded world study.

The wolf was located by Canadian scientist in April 1988 and remained in Canada. The straight line distance between capture and kill site was 4343 miles. The longest distance previously known to have been traveled by a wolf in North America is just over 450 miles.

Among the 51 marked wolves in the study, the primary cause of loss from the study area was dispersal, although the population was subject to fairly extensive hunting and trapping.

The evidence points to #321 as being *truly* "a lone wolf."

* * *

One of the radio-collared wolf packs in Denali NP&P has left its established territory and traveled 140 miles. This pack numbered 14 animals within a 800 k2 territory in the center of the park. Eleven wolves, including 3 radio-collared animals, crossed the Alaska Range and moved through at least 4 other wolf pack territories, along the way making several caribou and moose kills.

While wolf pack forays into other territories have been observed, movement of nearly all of a pack for such a long distance has not previously been recorded in Denali. The pack broke into smaller groups during the summer. Their subsequent movements, including whether or not they return to the park, will be of considerable scientific interest.

Western Region

The CPSU at U/AZ announces a newsletter called *Bajada.* Its purpose is to provide a new medium of communication for researchers and managers working in the parks administered by the CPSU at Tucson. The first issue will appear in January 1993. A circular announcing *Bajada* and listing guidelines and deadlines is available to contributors by writing the CPSU or calleing (602)670-6896. You may also call or write to have your name placed on the circulation list.

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Tech. Report #45, "Natural Vegetation of Casa Grande Ruins NM, AZ," by K. Reichhardt (40pp) has been published by the CPSU at U/AZ and copies may be obtained by writing there or calling (602) 670-6885.

An article titled "GIS Research in Arizona NPS" by Michael Kunzmann, Phil Guertin, and Tom Potter, was published in the Spring issue (Vol. 4, #1) of *IDRISI NEWS.* It discusses Arizona GIS research and explains why IDRISI was chosen as the principal GIS system to create GIS databases for several of the AZ NP units. For copies of this 2-page article, call (602) 670-6885.

* * *

Mary Ann Madej, Research Geologist at Redwood NP, has two new publications: "Spatial variation in armouring in a channel with high sediment supply," pp. 277-296 *in* Dynamics of Gravel-Bed Rivers, P. Billi, R.D. Hey, C.R. Thorne, and P. Tacconi, eds. John Wiley and Sons. NY 670 p.; and "Cooperative erosion control efforts based on sediment transport trends, Redwood Creek, north coastal California," *in* Proceedings of the American Institute of Hydrology Conference, Portland, OR, 1992.

Rocky Mountain Region

Leafy spurge (*Euphorbia esula*), a highly competitive exotic species and noxious weed, has continued to spread within Theodore Roosevelt NP (TRNP) despite several years of herbicide spraying, causing significant ecological disruption of native communities and, in some localities, replacing all native species.

TRNP in 1987 began an experimental biological control program consisting of several insect species that are natural predators on leafy spurge in eastern Europe. This year the park initiated an intensive biocontrol program, working with USDA Agricultural Research Service (ARS), USDA Animal and Plant Inspection Service (APHIS), North Dakota Dept. of Agriculture, and the ND State University (NDSU).

Recently the park released three different flea beetles – 6,760 *Aphtona flava* at 16 sites (ARS and NDSU), 4,500 *Aphthona nigriscutis* at 5 sites (ARS and NDSU), and 2,000 *Aphthona cyparissiae* at 3 sites (ARS). APHIS is continuing to provide the park with information on the testing of identified biological control agents released in the park and their potential effect on native spurges. ARS is clearing 5 additional new species of biocontrol agents through APHIS.

Biological control agents will not eliminate the spurge, but the goal is to reach an acceptable ecological balance between spurge and the native plant communities. Large scale use of biocontrol is probably 10 years away.

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Continued on page 16

Midwest Identifies Social Issues As Aid In Planning Research Program

By Roak Parker, David Lime and Jerrilyn Thompson

NPS managers face a wide range of management issues that impact both cultural and natural resources. Many of these issues are social in nature. We define *social* issues as those concerned with the management of human actions and interactions, such as dealing with human-induced erosion along river shorelines, monitoring numbers and types of visitors, developing effective visitor education programs to encourage minimum impact behaviors, and developing cooperative strategies among individual park units and various governmental and nongovernmental agencies.

Social science research can aid resource management in seeking solutions to many social or human issues. But what exactly are these social issues? Are issues unique to individual park units, or do many park units experience similar problems? And which issues deserve priority?

To develop management strategies for social issues in the NPS Midwest Region, the newly established University of Minnesota CPSU was called upon to identify social science research needs and opportunities as they relate to emerging issues within the Region. As a first step in identifying what issues exist and whether or not there are common problems among park units, the CPSU systematically examined 6 major planning documents for the 28 units in the Midwest Region that had completed planning documents.

Planning documents provide direction and focus for park management. Their content and style varies considerably and often reflects the educational background of the authors. Many are written from a biological perspective, and they focus on the manifestation rather than on the cause of the problem – especially when the problem is caused by visitor impacts. As a result, many social problems and issues may not be readily evident or directly stated. Nevertheless, this effort was viewed as an early and exploratory step to help identify a research agenda and isolate priority issues for study using one source of information.

For each of the 28 parks studied, the contents of each Resource Management Plan (including natural and cultural resources), Interpretive Prospectus, Statement for Interpretation, Statement for Management, and 1990 Outline for Park Requirements were analyzed. All of the social issues or problem statements expressed directly and indirectly in these documents were recorded and later classified into 6 broad categories dependent upon their content:

1. describing use and users;
2. providing for interpretation;
3. describing aesthetic, economic, and psychological benefits;
4. managing visitors;
5. managing external influences; and
6. other issues, not fitting these categories.

Once placed in an initial category, issues were reexamined. Within each of the 6 broad categories, major themes were identified and some categories were subdivided into specific issue groups, such as managing depreciative behavior, determining economic benefits of park use to the local economy, and developing cooperative arrangements with other governmental agencies. The range of issues and the extent to which issues are common among park units were identified.

As a check on the responsiveness of our findings, the initial results for each park unit were sent to the park superintendent for review and comment. The superintendent was asked to do 5 things: (1) cross out any problem statements or issues that already had been clearly addressed and resolved, (2) clarify the wording for any problem statement or issue that did not accurately reflect the problem, (3) add any social problems or issues to the list which were not identified, (4) indicate the issues they would like help in resolving, and (5) rank order the issues they had identified in item 4. Comments from the superintendents were used to amend our findings and to more accurately reflect each park's situation.

General Results

From the 168 documents examined, more than 300 issues were identified, averaging about 10 per park. For example, within the broad category of Providing for Interpretation, more than 100 separate issues emerged. Approximately 85 issues were identified concerning Managing Visitors, and 50 issues were found concerning Managing External Influences. Many of the specific issues in these last two categories occurred in more than one park unit. Within the other three categories, fewer issues were identified. For instance only 23 problems emerged in the category Describing Aesthetic, Economic, and Psychological Benefits, with almost half of these being added by park superintendents during the review process.

The number of issues identified per park unit varied widely, ranging from 47 at Voyageurs NP in Minnesota to one at George Rogers Clark NHS in Indiana. Although the park superintendents added to and amended the issues identified for their units, these changes did not significantly alter the general results.

A Diversity of Issues

Given the diversity of park settings within the region, a variety of social issues was expected and found. The individual issues identified ranged from the need to control vandalism within the parks to the need to determine the aesthetic value of open spaces.

While there is a great diversity of issues and types of issues, it also is clear that many issues are unique to individual park units. All but one park unit identified at least one issue that was not identified at any other park. Many of these issues focused on the unit's need for research, development, and evaluation of interpretive programming. For example, at Jefferson National Expansion Memorial there is an expressed need to conduct oral histories about the building of the arch as an aid to interpretation. At Voyageurs NP a need was expressed to add authenticity to interpretive programs through interviews with Native Americans.

While strategies and methods to conduct such research may cross park unit boundaries, the immediate value of the research will be to the individual unit.

Common Issues

Individual park superintendents and managers may be well aware of the problems faced by their own units, but they may be less aware of management problems and issues in other units. To each manager,

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regional highlights

Wind Cave NP's thistle problem (common to many park areas) cannot be attacked by use of herbicides, owing to the fact that the cave underlies a large part of the park and herbicide contaminated water might infiltrate the cave environment. Thus, the thistle (*Circium arvense*), has been manually cut in past years. Dr. Deborah Kendall, Fort Lewis College, is using insects that feed specifically on Canadian thistle to control spread of the plant.

Research and control plots were established and releases of the Canada thistle gallfly (*Urophora cardui)* took place in May and June. Releases of the Canada thistle seedhead weevil (*Larinus planus*) were accomplished in July. Monitoring has shown they are well established and doing considerable damage to thistles in the research plots. A third species, the Canada thistle crown root and stem weevil (*Ceutorhynchus litura*), slated for release, was unavailable. It is hoped this project can continue next year to insure establishment of these species.

* * *

The southwestern subspecies of the Willow Flycatcher (*Epidonax traillii*) has been categorized as a Species of Concern and is being proposed for listing as endangered or threatened. Population declines have been caused by riparian habitat loss and brood parasitism by the brown-headed cowbird (*Molothrus ater*). Surveys now being conducted by the Resource Management division at Glen Canyon NRA and biologists from Northern AZ/U will give managers the baseline data for understanding and managing willow flycatcher populations along the Colorado.

* * *

Glen Canyon NRA harbors a wide variety of riparian vegetation in side canyons and major tributaries. As part of the ongoing riparian vegetation survey work around the lake, sites will be selected for breeding bird monitoring studies, to start in Spring 1993. This will provide initial baseline data on extent, composition, and status of riparian breeding birds around the lake.

* * *

Several of the Region's park units are monitoring neo-tropical migratory birds in conjunction with other agencies as part of the national interagency Neo-tropical Migratory Bird Conservation Program. Glacier NP is conducting songbird monitoring in cooperation with the USFS. Zion NP is cooperating with the Utah DNR to monitor birds in riparian habitats, and Glen Canyon's monitoring program will complement efforts by other southwest agencies.

* * *

The Branch of Research has hired Ed Wick as Endangered Fisheries Program Coordinator with the developing CPSU at Colorado State U in Fort Collins. Wick will concentrate on the 4 endangered fish species in the Upper Colorado River basin.

Table 1. *Selected social issues identified in Midwest Region park planning documents.*

Park Unit	Need to monitor visitor use patterns	Need to reduce and manage depreciative behavior	Need to manage user conflicts	Need for agency cooperation	Need to address issues adjacent to parks	Need to understand economic benefits of park use
Agate Fossil Beds National Monument	x			x		x
Apostle Islands National Lakeshore	x	x	x			
Cuyahoga Valley National Recreation Area	x	x	x	x	x	
Effigy Mounds National Monument	x	x		x		
Fort Larned National Historic Site	x	x	x	x	x	
Fort Scott National Historic Site					x	x
George Rogers Clark National Historic Park					x	
George Washington Carver National Monument					x	
Grand Portage National Monument		x				
Harry S. Truman National Historic Site	x			x		
Herbert Hoover National Historic Site	x			x		
Homestead National Monument	x			x		
Indiana Dunes National Lakeshore	x	x	x	x	x	
Isle Royale National Park	x	x	x			
Jefferson Expansion Memorial National Historic Site	x				x	
Lincoln Boyhood National Monument	x	x		x	x	
Lincoln Home National Historic Site	x			x		
Mound City Group National Monument					x	
Ozark National Scenic Riverways	x	x	x	x	x	x
Perry's Victory International Peace Memorial		x	x		x	
Pictured Rocks National Lakeshore	x		x			x
Pipestone National Monument			x			
St. Croix National Scenic Riverway	x	x	x	x	x	
Scotts Bluff National Monument	x		x		x	x
Sleeping Bear Dunes National Lakeshore	x	x	x	x		
Voyageurs National Park	x	x	x			
William H. Taft National Historic Site				x		
Wilson Creek National Battlefield	x	x	x		x	
Total number of issues identified:	20	14	14	14	14	5

x = Park unit indicated a need to address an issue in one or more planning documents or from review of initial study results by park staff.

the seemingly exhaustive list of problems can appear to be unique. Thus, it would not be surprising to discover that many managers are less concerned with the "unique" issues that arise at other park units.

Our analysis indicates that many specific issues are *not* unique but are common among park units. Without exception every park unit in the region shared at least one specific social problem with one or more units; park units as diverse in setting and programming as Jefferson NEM and Voyageurs NP share specific social problems and issues.

In Table 1, 6 specific issues illustrate the number and types of issues shared among the units of this region. The need to *monitor visitor use* comes from the broad category of Describing Visitor Use; the need to manage or reduce *depreciative behavior* and to understand and manage *user conflicts* comes from the broad category of Managing Visitors; the need to develop or improve *cooperation with other agencies* and the need to address issues of *adjacent land use* come from the category of Managing External Influences, and the need to understand *economic benefits* related to park use comes from the broad category of Describing Economic or Aesthetic Benefits.

Twenty of the 28 parks indicated a need to know better who are their visitors, how visitors use the park, and to document trends over time (Table 1). Half the parks indicated a need to control depreciative behavior, to manage visitor conflicts, to improve cooperative arrangements with other agencies, and to influence or participate in the management of lands adjacent to and near park boundaries.

The general category Managing External Influences had two components, listed in Table 1 as *need for agency cooperation* and *need to address issues adjacent to parks.* Only 7 parks did not show a problem for one of these categories.

Because park units in the Midwest Region share many similar problems, research strategies should be explored in a regional context rather than on a park unit by park unit basis. For example, visitor use monitoring systems could be developed for Great Lakes national lakeshores and parks to document and analyze trends as well as to explore the degree to which visitors use individual or multiple parks in this regional system.

A more specific regional study is underway by the Minnesota CPSU that addresses how these perceptions could be translated into both natural resource management and interpretation programs. Phase one of this study is focusing on lighthouses at Apostle Islands National Lakeshore, but the study will be expanded to include a series of Midwest Region lighthouse sites that represent a range of natural resource settings, different intensities of visitor use, and varying levels of managerial response. Such regional studies could be more cost effective and could lead to increased generalization of research methods and results within the region and elsewhere in the national park system.

Further Studies Are Planned

While this exploratory research found that a wide range of social problems exists within the Midwest Region and that many problems cut across park units, it is not clear how responsive this analysis is with regard to actual research needs. Although information received from the superintendents following their review of our findings helped insure that the data reflect actual conditions in the parks, this research gives only an indication of the emerging issues in this region. Additional research seems warranted to identify emerging issues more accurately and to aid in developing a social science agenda.

A logical next step would be to survey or interview park superintendents, rangers, and other staff about their perspectives on emerging issues in park planning and management. Additional study participants could include private environmental groups, state departments of natural resources, commercial sector providers of leisure services, and selected recreating publics. Such a study of NPS employees in the Midwest Region, and perhaps others, has been initiated by the U/MN CPSU.

A survey or modified Delphi approach, which asks respondents to reply to a series of questions, has been found effective as a way to identify and prioritize emerging issues needing study (Gregersen et al. 1989). An initial open ended questionnaire or letter asks respondents what they think are the most important emerging issues facing NPS managers and users over the next 10 to 15 years. Follow-up questionnaires, interviews, workshops, or focus group meetings are planned.

Workshops or meetings would address prioritized topics in more detail; explore what is known and not known about issues of critical interest; develop priorities for field studies, and develop strategies to attack issues for which adequate information is not currently available. Particular attention would be given to multi-park studies to strengthen broader application and transferability of results among park units. These results could be compared with those from the review of planning documents to aid in prioritizing social science research needs.

This research also will seek to develop and test an information-retrieval system as a means of improving dissemination and application of research results. It is anticipated that one or more priority issues will be studied for which information exists but has not been effectively transmitted to or used by field managers.

Parker is a research assistant, division of recreation, park and leisure studies, school of kinesiology & leisure studies, U/MN; Lime is a research associate and NPS/CPSU leader at U/MN; Thompson is a research specialist with the NPS/CPSU.

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Mercury Threatens Wildlife Resources

By William Loftus and Oron Bass, Jr.

In recent decades, our national park areas have faced a previously unrecognized threat – the introduction of contaminants from external sources often distant from park boundaries. The effects of long-range transport of contaminants, which contribute to acidic deposition, ozone damage, and impairment of scenic resources, have become obvious to park employees and visitors alike. National parks also have suffered from point and nonpoint source pollutants entering parks in waters shared by cities, industry, and agriculture.

The NPS has responded by instituting research and monitoring programs with the guidance and participation of the Air and Water Resources divisions. NPS also is a major player in the National Atmospheric Deposition Program. Individual parks, to maintain their air and water quality standards as required by the Clean Air and Clean Water Acts, often work closely with other federal and state agencies to monitor physical and chemical parameters.

Although NPS has programs to monitor the status of park air and waters, the contamination situation described in this report strongly indicates that present monitoring programs are inadequate to detect ecotoxicants that accumulate in park biota. This case history deals with mercury, but applies as well to other bioaccumulated heavy metals and pesticides. We hope the mercury case history in the Everglades will demonstrate the need for periodic testing of the biota for contaminants (biomonitoring) to improve chances of detecting a problem before symptoms occur.

Mercury (Hg) is a heavy metal found naturally in air, water, and earth in a number of chemical forms. It is very volatile, easily entering the atmosphere where it may be dispersed widely (Swain, 1989). The biota accumulate mercury in body tissues, through which it is passed to higher trophic levels in the food web (Johnels et al.,1967). Top-level carnivores may accumulate loads at which toxic effects, such as nerve damage, convulsions, and death occur. The U.S. Food and Drug Administration presently sets a maximum limit of 1.0 ppm Hg in human foods. Methylmercury is the most toxic and accumulatory mercury compound. It is believed to be produced by the microbial methylation of Hg in aquatic systems (National Academy of Sciences, 1978).

The first hint that Hg was present in Everglades NP (EVER) came during the DDT-scare of the early 1970s. Ogden et al. (1974) presented the results of screening a variety of wildlife for pesticides and heavy metals. They expressed concern about the biotic effects of Hg because levels in some freshwater fishes averaged between 0.6 and 0.9 ppm. Levels in eggs from wading birds and alligators ranged from 0.4 to 0.5 ppm Hg, and exceeded 1.0 ppm in some wading bird tissues. Ogden et al. (1974) suggested that the biota be monitored for contaminants every 2 or 3 years, but for reasons unclear to us their suggestion was not heeded.

In 1989, a statewide sampling program for Hg in freshwater gamefish by the Florida Game and Fresh Water Fish Commission revealed that muscle filets from largemouth bass (*Micropterus salmoides*) in the Everglades had the highest levels (x>1.0-1.5 ppm) in

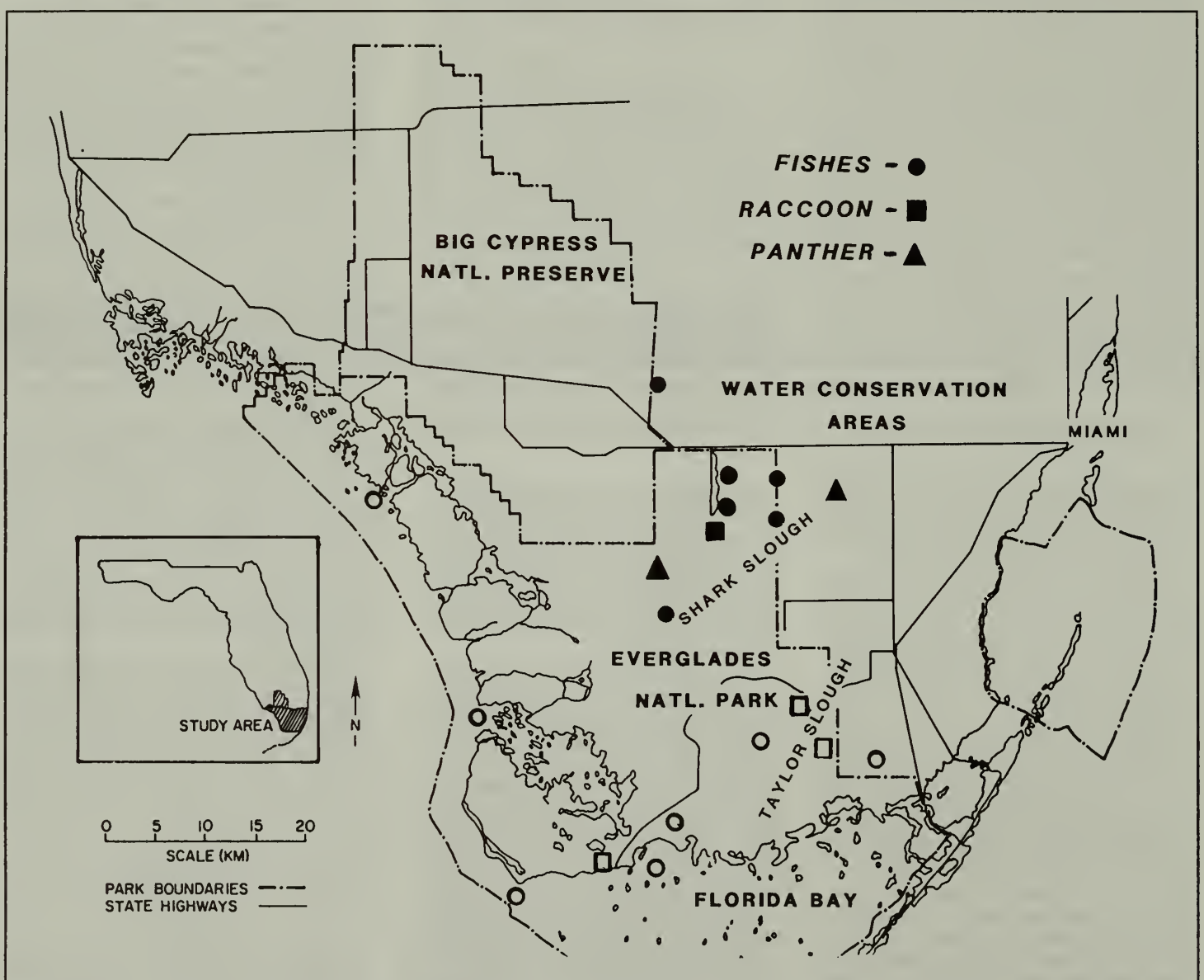

Figure 1. Extreme southern Florida, showing the major deainage areas in and near Everglades NP. High (closed sympols) or low (open symbol) mercury levels in tissues from fishes, raccoons, and the Florida panther, show the pattern of association with Shark Slough.

And Human Health in Everglades NP

the state (Hand and Friedemann, 1990). Consumption advisories for fishermen were issued by the Florida Dept. of Health and Rehabilitative Services. EVER cooperated with the USFWS to analyze bass and yellow bullhead catfish (*Ameiurus natalis*) samples at their Columbia, Mo. lab. Bass from Shark River Slough, downstream of the Water Conservation Areas, had the highest levels (x=1.706-1.847 ppm); Taylor Slough drainage bass had lower levels (x=0.511-0.603 ppm) (Fig. 1). Park managers responded by issuing a brochure explaining the threat to human health. The consumption of bass from Shark Slugh waters was prohibited and was restricted in other park waters.

Signs warning of contamination were posted at popular angling sites. Because the greatest fishing activity and harvest occur in saltwater areas, higher trophic-order gamefishes like spotted seatrout (*Cynoscion nebulosus*) and gray snapper (*Lutjanus griseus*) were tested next. Fortunately, mercury levels were lower than in the freshwater fishes (x=0.112-0.586 ppm), and seemed to pose no human health threat.

Until late in 1989, the emphasis for action focused on the human health issue. However, this changed with the death of Florida Panther #27 (*Felis concolor coryi*) in the summer of 1989 in Shark Slough (Fig. 2) (See ***Park Science*** 10(4):15). Autopsy results were inconclusive but revealed that the cat had regurgitated prior to death. Results of the liver scan revealed an incredible 110.0 ppm of Hg, much higher than liver values from panthers killed by automobiles or other causes. Again, the Shark Slough link was evident.

Mercury contamination in this highly endangered species is of great concern because of its small population, estimated at fewer than 30 individuals in the wild. Blood and hair samples taken from free-living cats using Shark Slough showed a similar pattern of high Hg levels (Fig. 1). Bioaccumulation of Hg through the panther diet was suggested as the source for the high levels. Panther #27, which lived in the Shark Slough area, fed heavily on raccoons (*Procyon lotor*) and alligators (*Alligator mississippiensis*), which in turn, fed on fishes and invertebrates. Panthers in other areas prey on whitetail deer (*Odocoileus virginianus*) as a staple, and deer have very low Hg levels (Roelke et al., 1992).

The next step in the investigation determined that raccoons from Shark Slough had higher levels than those living elsewhere (Fig. 1). Alligator samples await analysis but are likely to be high. In the northern Everglades, the alligator hunting season was closed because of unsafe Hg levels. Most recently, great egrets (*Casmerodius albus*) and other waders from Shark Slough had the highest Hg levels of samples tested from south Florida (M. Spalding, U/FL, pers. comm.).

Two major questions raised by this episode are (1) what are the sources of Hg contamination, and (2) what factors contribute to its mobilization and cycling in the environment. An association of high Hg levels in animal samples from Shark Slugh is the presence of peat or muck soils in the central depression of the Everglades. In studies of Hg contamination in Scandinavia and the northern U.S. (Swain, 1989; Hand and Friedemann, 1990), association between peat substrates and high Hg levels has been indicated, especially when the peats were mixed or disturbed in some way. Presumably, disturbances liberate Hg stored over time in the peats, making it available for methylation and food-web transfer.

Figure 2. *Remains of Florida Panther #27 found dead in Northeast Shark Slough.*

The northern quarter of the original Everglades system, known as the Everglades Agricultural Area (EAA) was converted to agriculture decades ago. Two major farming activities in the EAA which may release Hg by disturbing the soils are sugarcane production and sod growing. Before the sugarcane harvest begins, thousands of hectares of fields are burned, sending huge plumes of smoke skyward. The processing mills are fueled by burning cane wastes. A recent report showed that sugarcane tissues contain Hg at levels of 0.03-1.2 ppm (Simons, 1991). As part of the growing cycle, the fields are alternately flooded and dried, leading to rapid oxidation of the peats and the release of stored Hg. Sod production in the EAA also results in peat disturbance and loss. The liberation of either natural or anthropogenically produced Hg from storage in peats may be a major source of contamination elsewhere in the system.

The metropolitan and agricultural areas of Florida's east coast, from Palm Beach to Homestead, are home to more than 4 million people, who use Hg in products such as batteries, dental materials, and fungicides in latex paints. All these uses represent *nonpoint* sources of a volatile metal easily transported by winds. There also exist *point* sources of Hg, such as fossil fuel-fired power plants (Joensuu, 1971) and waste incinerators. A study contracted by the NPS Air Quality division estimated that one of the power plants may emit several thousand kg of Hg annually (Gough et al., 1986). Another study, which modeled wind tracks over the Everglades in summer and winter, demonstrated that Hg emitted along the east coast would be transported over the Everglades (Segal et al., 1986).

Biocontaminant sampling and research is costly; unfortunately most parks do not have the fiscal resources to address this issue. EVER is participating with the state task force assigned to address and manage the episode, but the task force suffers from insufficient funds. To continue periodic monitoring and research, NPS must fund some of the work. The implications of mercury biocontamination are frightening. If we do not understand the sources or the processes, there will be no way to correct them, leaving the region with a chronic contamination situation.

Because of the potential threat to the few remaining wild panthers in the Everglades, the Florida Panther Interagency Committee has recommended removal of at-risk panthers into captivity; no action has yet been taken. The past few years have seen notable reproductive failures and some developmental anomalies in alligators and wading birds as well. Interpretation of these findings is confounded by the coincidence of several years of extreme drought, but because of the evidence, the synergism of Hg must also be considered.

National parks are not immune from the waste products of the society surrounding them. The lesson of the Hg incident is clear. Even if air and water quality monitoring is intended to measure heavy metal or pesticide levels in the environment, those levels may be so low that their potential impacts on wildlife are not appreciated. We believe NPS must fund periodic biomonitoring for contaminants to identify problems *before* symptoms appear. The most efficient means is by sampling indicator organisms near the top levels of food webs, where symptoms are most likely to be manifested. The price of ignoring contaminant biomonitoring is the potential of discovering that the biotic resources of the park are being quietly but inevitably poisoned.

Bass is a Wildlife Biologist and Loftus is a Fishery Biologist on the staff at Everglades NP.

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Study Links Big Cypress Fox Squirrel To Golf Courses

By Patrick G.R. Jodice and James R. Snyder

The Big Cypress fox squirrel (*Sciurus niger avicennia*) is one of the distinctive animals of Florida's Big Cypress National Preserve (BICY). One of 10 subspecies of fox squirrel, the Big Cypress fox squirrel (BCFS) is endemic to southwest Florida, with a large portion of its range occurring in and around BICY. Although fox squirrels as a species have been well studied since the early 1900s, southeastern fox squirrels have received little attention. Howell (1919) first described the BCFS, and Moore (1956, 1957) published short accounts of its natural history. Williams and Humphrey (1979) conducted a field survey based on interviews with local residents and found that densities of BCFS were very low.

Concern over the animal's status was sufficient for Florida to prohibit hunting in the 1970s and place it on the state's threatened and endangered species list. A resource inventory and analysis done soon after creation of BICY (Duever et al. 1979) expressed optimism that elimination of fox squirrel hunting and improved law enforcement would allow the BCFS population to increase. Unfortunately, in the 1980s some well known local populations disappeared and the number observed in the Preserve did not increase. The animal is currently a candidate for federal listing.

Squirrel Project Funded

In 1988 BICY received funding for rare and endangered species research, developed a statement of work for a fox squirrel study, and contacted Dr. Stephen R. Humphrey of the Florida Museum of Natural History, U/FL. He developed a proposal to study the distribution and habitat use of the BICY by the squirrels. The project also planned to recommend methods for a monitoring program and management actions that would benefit fox squirrels in the Preserve. Field surveys were to be conducted over a 1 year period and data on population locations, density, diet, and habitat use were to be collected.

The senior author (Jodice) arrived in south Florida as a graduate research assistant in January 1989, to carry out field work. He began surveying a large system of pinelands in the BICY interior. Within a few weeks he located one fox squirrel at a pineland/cypress ecotone, but although the site was visited daily for the next few weeks, the squirrel was not seen again. Surveys continue throughout BICY, but it was several weeks before the next squirrel was sighted. Densities seemed low indeed!

***Bromeliad clumps** like this one, on the trunk of a cypress tree, are the temporary nest sites of choice for fox squirrels.* (Photo by Jim Snyder.)

It became apparent that field surveys would not yield the quantity or quality of data needed. Surveying for squirrel leaf nests, a proven technique for locating squirrels elsewhere, also was unsuccessful. After 4 months we had little more information than when we started and less than 8 months to go before the end of the allotted field time.

Golf Courses Eyed

We began to focus on other populations of BCFS. We knew there were fox squirrels living on and around golf courses in the rapidly developing Naples area 50 km west of BICY. The animals were easy to locate and observe, and preliminary surveys raised interesting issues. For instance, only certain golf courses in town had fox squirrels. Golf courses also seemed to supply a wide variety of food (mostly in the form of exotic plantings) not available in BICY. We saw the golf courses as an opportunity to gain valuable natural history information on mating, daily and seasonal activity, and diet.

We decided to invest some time in the golf course populations. By spending 1 or 2 days a week on the golf courses we hoped to supplement our knowledge of BCFS and gather information on an important segment of the subspecies. Time constraints and lack of natural history knowledge led us to focus on squirrel activity patterns and diet at just 4 well-populated courses.

In the summer of 1989 another opportunity presented itself. A Naples resident was complaining about a group of fox squirrels living around her yard and eating her bird seed. She asked if the Florida Game and Fresh Water Fish Commission could remove them. Aware of our ongoing research, the state contacted us and we decided to relocate the squirrels to suitable habitat within BICY. We trapped, radio-collared, and released 5 squirrels over 3 months. We hoped this translocation would (1) lead us to other fox squirrels, and (2) provide insight to habitat use and diet.

Ranges Expanded

Near the end of our scheduled field season a modest increase in funding made it possible to collect a full year of golf course data and 8 months of radiotelemetry data. Results from the translocation showed that fox squirrels could cover large distances in short time periods. They traveled both on the ground and through the trees. Much of this movement may be due to the squirrels' relocation; nevertheless it demonstrated their ability for extensive areal coverage.

Although comparisons with other studies are complicated by differences in methods of estimating home range size and the fact that these squirrels were translocated, it seems that avicennia may be using a larger home range than fox squirrels in other areas. The mean of 2 translocated BCFS home ranges was 59.6 ha (conservative estimate). This is greater than any other home ranges reported for all subspecies of fox squirrel. We feel that the habitat mosaic of BICY (predominantly pine, cypress, and mixed-swamp forests) presents a sparser food source for BCFS than for fox squirrels in typical pine/hardwood habitat. This could cause home-range sizes and movements of BCFS to be greater than those of fox squirrels in other habitats (Jodice 1990).

Habitat use of translocated fox squirrels varied among seasons. The translocated fox squirrels used wetter habitats (cypress and mixed-swamp forests) until water levels receded in mid-January. As water levels decreased, fox squirrels foraged predominantly on the ground.

From mid-January through mid-April (the termination of telemetry studies), fox squirrels were often observed digging shallow pits at the base of pine trees, indicating that they were obtaining hypogeous fungi, an important winter and early spring food item for southeastern fox squirrels (Weigl et al. 1989). Few other foods are available in these months. Pine seeds, a staple summer food, are not available until early June.

Nesting Behavior

Perhaps the most important information obtained from the telemetry project dealt with fox squirrel nesting behavior. Translocated fox squirrels rarely used leaf or cavity nests, but instead nested in cabbage palm crowns and in clumps of bromeliads (tropical epiphytes in the pineapple family) growing on cypress trees. The latter two nest types require little or no construction. This may allow fox squirrels to range over large areas without the need to build nests on a daily basis (an activity that could take up to 2 hours). Squirrels (both fox and gray) often strip bark from cypress trees for incorporation into the cabbage palm or bromeliad nest (Jodice 1990). Surveying areas for stripped cypress trees will become a useful technique for locating squirrel activity in BICY.

One translocated male fox squirrel did lead us to a "native" fox squirrel. In mid-March we located our radio-collared fox squirrel pursuing a female in a previously unsurveyed area. We located 2 nests and observed the female trying to raid a bluebird nest. We were unsuccessful in trapping that female for telemetry, but we gained valuable information and developed new ideas for trapping.

The above data from translocated fox squirrels may

Mercury Threatens

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Fox Squirrel Study

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provide insight into habits of resident fox squirrels. Habitat use and home range size of resident Big Cypress fox squirrels still are unknown. However, should this information become available, even a qualitative comparison between resident and translocated fox squirrels would shed valuable light on the feasibility of future translocation projects.

Adaptability Demonstrated

The results of the golf course project indicated how readily fox squirrels have adapted to a situation very different from their natural habitat. There were seasonal differences in the amount of time golf course squirrels spent foraging or inactive, but the differences were not correlated with seasonal changes in either diet or weather. These results indicate that food may not be seasonally limiting to fox squirrels on golf courses that have mixtures of native and exotic plant species.

We speculate that the seasonal shift in time spent foraging may relate to the breeding cycle, specifically young-rearing. Copulation was observed in early and mid-July 1989. The 42-day gestation period of fox squirrels would have placed births in mid-August through early September and lactation through November. During lactation, energy requirements of female fox squirrels increase, resulting in increased foraging time (Weigl et al. 1989) as we observed in the early fall.

The golf courses we studied in southwestern Florida, with their exotic species and artificially maintained habitats, provided fox squirrels with relatively stable food sources ... unusual both in its diversity within seasons and its uniformity among seasons. Unlike fox squirrels in natural habitats in the southeastern U.S., fox squirrels on golf courses did not rely on any single food item for a season (Jodice and Humphrey in press). Instead, they relied on various planted fig species throughout the year. Exotic queen palms and bottlebrush also were important food items.

Native food items of importance were pine seeds (July-September) and cabbage palm fruits (December and January). Cypress cones, a primary food item for fox squirrels in BICY, were rarely observed being eaten on golf courses. Cypress may not be a preferred food, but one consumed only when little else is available (as seems the case in many areas of BICY in the autumn months).

Questions Remain

Questions remain about the long-term viability of golf course populations of fox squirrels. It is possible that existing populations are taking advantage of natural habitat still existing on undeveloped lands adjoining the golf courses, and it is certain that continuing development will greatly reduce the availability of this natural and semi-natural habitat to urban squirrels. S.R. Humphrey has submitted a grant proposal to the Florida G&FWF Commission's Nongame Wildlife Program to address this issue.

Given the low density of BCFS in BICY we recommend that a more extensive study of fox squirrel distribution be carried out opportunistically. In addition to reporting fox squirrel sightings, field biologists working in red-cockaded woodpecker colonies or searching for panther sign also can look for stripped bark on cypress trees and gnawed pine cones in the summer months.

Capture and radio-collaring of some of the elusive resident fox squirrels will be necessary for adequate study of habitat use, food habits, and population biology in the Preserve. In the meantime, the Preserve's aggressive prescribed fire program is likely to enhance habitat quality by maintaining open, healthy pinelands.

Jodice was a graduate research assistant with the U/FL Dept. of Wildlife and Range Sciences; he is now a Regional Nongame Biologist with the Florida Game and Fresh Water Fish Commission. Snyder is NPS Research Biologist at BICY.

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"Borrowing" Trouble

Editor's Note: The following article, while it does not describe scientific research, certainly has resource management as a central theme. It came from ***Einar S. Olsen****, Senior Environmental Protection Specialist with the NPS Washington Office of Mining and Minerals Branch and focuses the management spotlight on a problem heretofore not dealt with in these pages.*

Imagine this situation. You pull your car into a park overlook area. You have great expectations for the view of the broad valley and rugged maintain range, which rises abruptly on the valley's far side. But the scene and serenity are disrupted by a most *unexpected* obtrusion – a gravel operation, located in the floodplain of a river that bisects the valley. The noise from the stone crushing equipment and the constant arrival and departure of trucks hauling gravel to and from work sites is impossible to ignore.The view seems washed out, due to dust from the operation; the waters downstream are not as clear as those above the pit.

This is not an inholding or even a non-federal mineral operation on federal land. This is a National Park Service administrative borrow material site.

While this illustration may exaggerate somewhat, in-park use of borrow for administrative purposes is marring scenic views and needlessly damaging park resources. Borrow sites provide needed sand and gravel for park projects, including road, trail, and building construction and maintenance. Yet poorly developed and reclaimed borrow sites can have significant impacts on park resources, including degradation of water quality and stream channel stability, degradation of aquatic and terrestrial habitats, creation of conditions that promote invasion of exotics, disruption of wildlife, destruction of cultural resources, and the jarring of visitors' experiences.

While the Service is usually diligent in its protection of resource and visitor values, we do not always apply the same level of scrutiny to NPS projects that we apply to threats caused by others. This may result from the belief that since the project is being conducted by NPS, the impacts *must* be minimal or nonexistent. Unfortunately, in the case of administrative borrow sites, this has not been the reality. At several such in-park sites the NPS has violated the Clean Water Act and been ordered to cease operation.

Of several reasons for these shortcomings, one may be a result of problems with interpreting NPS *Management Policies*. Another may be the desire, for economic reasons, to use the closest gravel source. Also, local governments may pressure parks to use in-park sources so as not to deplete gravel sources in the surrounding communities.

NPS use of in-park borrow has not gone unnoticed by the conservation community. Non-governmental organizations always have advocated that administrative borrow sites should not exist in parks at all, regardless of importation costs of materials from other sources. Further, these organizations claim the NPS has violated various environmental laws and failed to follow its own policies.

As a result, the NPS Director issued *Special Directive 91-6* on Aug. 5, 1991, providing direction to parks on in-park use of borrow. The Directive's purpose is to ensure that all necessary issues, including economics, are considered prior to developing borrow pits, and that decision making is well thought out by park managers. The policy direction for the Directive comes from NPS *Management Policies*, Chapter 9, Page 4.

The Directive was prepared by a work group consisting of individuals from park natural resources and maintenance divisions, Regional Offices, Denver Service Center, WASO Water Resources Division, and WASO Mining and Minerals Branch. The final version was approved by the Director after being reviewed by the Regional Offices and parks.

The overall responsibility for implementing the Directive rests with the parks. If you have questions regarding it, please contact me, Einar Olsen, Mining and Minerals Branch, WASO, at 202/343-4968.

In The Next Issue

The U.S. Geological Survey will provide several articles based on earth science research in national parks. An assessment of dams and natural resources in NPS lands will overview the national program and describe the Lawn Lake Disaster at Rocky Mountain NP; the impacts of fires on water quality and sediment in Yellowstone NP will be described; other articles will deal with flow and sediment transport in the Colorado River between Glen Canyon Dam and Lake Mead, the long-term water quality of Lake Powell, stream biogeochemical responses to global climate change in Rocky Mountain NP, and 100 years of environmental change in the Grand Canyon.

Additional titles scheduled for Winter include "High Altitude Mountaineering at Denali NP: Visitor Profiles and Management Preferences" by Alan Ewert; "A Window to the Past: Prior Resource Management Provides a Framework for the Future" by Carol McNulty-Huffman; "Ecology of the High Mountain Black Bear Population at Rocky Mountain NP in Relation to Land Use" by Henry E. McCutchen; "Fort Matanzas National Monument: Home of the Anastasia Island Beach Mouse" by Philip Frank.

Marine Debris on NPS Beaches: A Plastic, Glass, Metal Nightmare

By C. Andrew Cole

The problem of marine debris has been around as long as humans have been discarding their solid wastes into the oceans. Lately, debris has become globally ubiquitous. Recent disclosure of medical wastes found on eastern beaches has heightened concerns about marine debris for both the general public and the scientific community.

Many environmental groups have shown concern. Each year the Center for Marine Conservation (CMC) sponsors a nationwide "Beach Sweep." This coordinated effort rallies volunteers for a few hours to pick up and catalog beach debris. Although the data from these efforts have been useful and have provided some important insights into the nature and variety of the problem, they are largely anecdotal (CMC 1990), and results from year to year are not necessarily comparable. Also, the sweeps being about a year apart, they leave considerable doubt as to what goes on between sweeps.

On the federal level, the National Marine Fisheries Service (NMFS) began systematic studies of derelict marine fishing debris in the early 1970s (Merrill 1984, Johnson and Merrill 1988). In an effort to expand on that information and generate a broader data base, NMFS and NPS have joined forces since 1988 to conduct a 5-year pilot program to monitor debris at 8 park units. Both agencies figured the NPS could provide relatively unaltered beaches for assessing types and accumulation rates of marine debris. The National Park Marine Debris Monitoring Program (NPMDMP) has been under way since fall 1988. This article describes some of the information realized to date.

Study Sites

Eight park units have been involved in the monitoring program. Olympic NP (OLYM) and Channel Islands NP (CHIS) represent the Pacific coast. Padre Island National Seashore (PAIS) and Gulf Islands National Seashore (GUIS) exemplify the Gulf of Mexico region. Canaveral National Seashore (CANA) and Cape Hatteras National Seashore (CAHA) illustrate the southeast Atlantic coast, while Assateague Island National Seashore (ASIS) and Cape Cod National Seashore (CACO) portray the northeast Atlantic coast. For the fourth year, the program has added Virgin Islands NP (VIIS), and is considering addition of Fort Jefferson (FOJE) in the Dry Tortugas, pending funding.

Methods

By using standardized survey methods and forms developed by NMFS and modified by the NPS, each park has been collecting data on debris since December 1988 (except for PAIS, as explained below). Although NMFS is primarily interested in plastic debris, the NPS is interested in all kinds, and so measured debris types include plastic, glass, metal, cloth, paper, and leather (the last 3 categories are typically lumped as "other"). In any one sample, therefore, 61 plastic, 5 glass, and 9 metal variables can be measured (along with cloth, paper, and leather).

At each park (again, except for PAIS), a minimum of 5 one kilometer beachers are surveyed. Selection of survey beaches considered accessibility, representation of regional conditions, distance from significant public access, and a uniform substrate and topography.

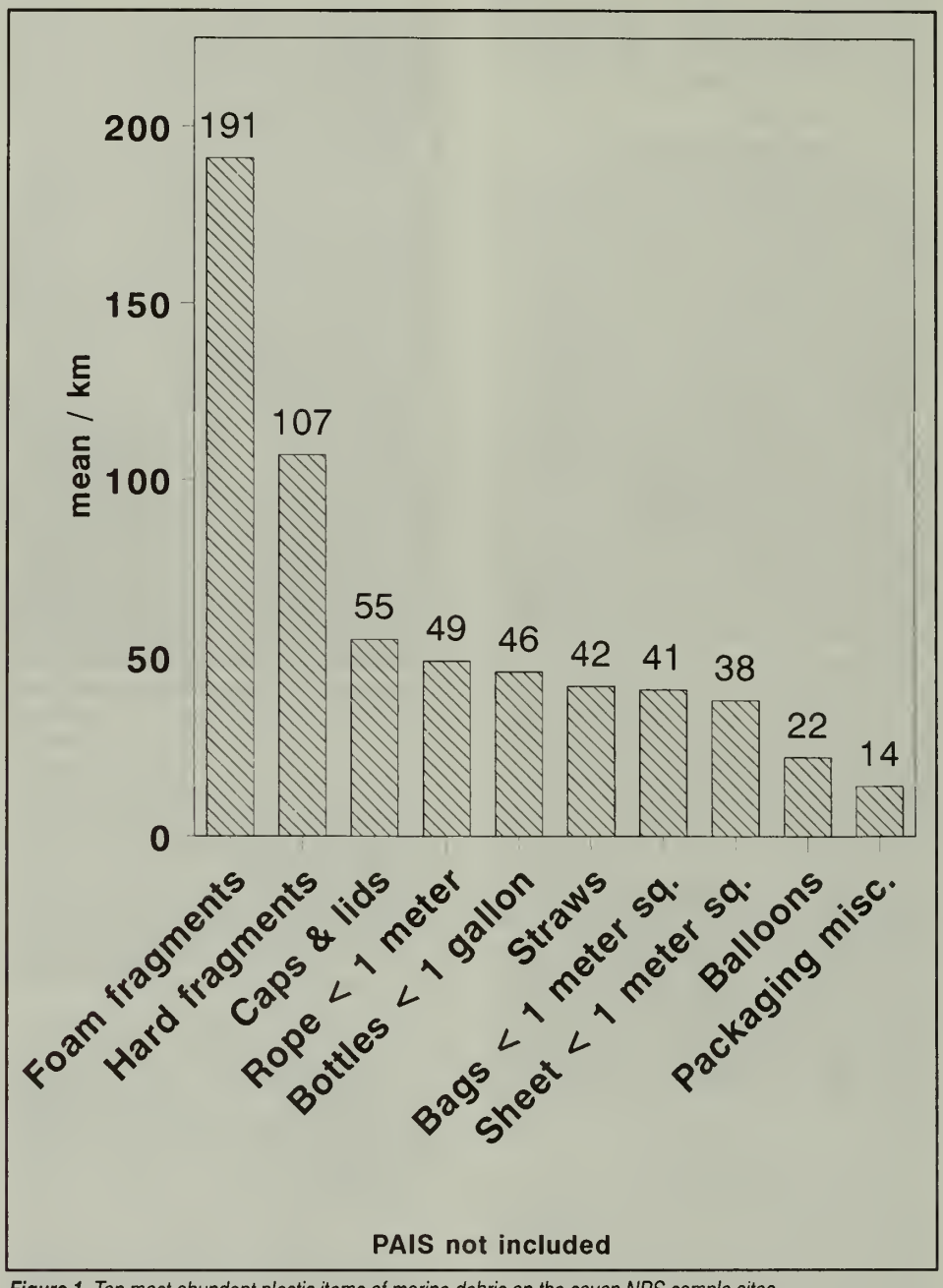

Figure 1. Ten most abundant plastic items of marine debris on the seven NPS sample sites.

On a quarterly basis, beaches are surveyed from the water's edge to the seaward limit of terrestrial vegetation, or to the base of a dune or a cliff. All debris visible from a walking height, and greater than 5 mm in length, is collected and recorded. Any item less than 1/2 its original size is considered a fragment. Hard plastic fragments, therefore, can be very large, unlike foam fragments, which typically are fairly small. This results in not including hard fragments as ingestible plastics, although quite clearly some are.

Ingestible items are those we feel are small enough to be readily eaten by by marine wildlife. Entanglement items are those large enough to entangle marine wildlife. In certain cases (e.g. rope < 1 meter in length) a judgment call was made not to include the item as entangling. If possible, all debris is removed from the beaches, thereby allowing for calculation of accumulation rates between samples. If articles cannot feasibly be removed (e.g. a large buried net), they are marked with paint for identification and non-inclusion in future surveys.

The most egregious local conditions are found at Padre Island; so much debris is found there that entire sets of surveys for consecutive quarters had to be canceled. Until recently the park simply did not have the time, money, or personnel to handle the mess. This (and other problems) resulted in the non-comparability of data for PAIS for the first 2 1/2 years of the project. However, a revised sampling protocol specifically designed for PAIS, plus additional outside funds from

EPA, have allowed the seashore to return to the sampling program.

Results to Date

As expected, most recorded debris at all beaches has been plastic. Values range from 97 percent at OLYM to about 67 percent at CAHA. Of those plastics, most common are foam fragments, hard fragments, caps and lids, rope < 1 meter, and bottles < 1 gallon (Fig. 1). By far the most common entangling item has been pieces of rope, while foam fragments clearly are the most frequent ingestible item found (Fig. 2).

Due to the variability we have encountered, definitive statements as to trends are impossible; still, some trends seem evident. Packaging appears to be declining in abundance, whereas the miscellaneous category is growing. Plastic, as a whole, also seems to be increasing as a percentage of total debris, though for individual parks there does not appear to be much of an increase in total debris (except for OLYM).

Average number of debris items per km varies widely among parks. Although not included here (due to problems already discussed), PAIS clearly has the most debris per km. In those parks where we have comparable, multi-year data, mean numbers of debris items per km range from 1392 (CACO 1990-91) to 223 (CAHA 1990-91).

Future Directions

It is clear that deposition of marine debris on the 8 parks is a highly variable phenomenon. The information to date, however, does provide useful documentation. For example, few parks seem to have much aesthetic degradation from debris. Even though there may be much of it, generally items are small and relatively inconspicuous.

Levels of medical debris are extremely low. Exceedingly few items have been found and they constitute much less than 1 percent of the total catalogued to date. This is an important finding, as medical debris, when found on beaches, is a public relations nightmare.

Although entangled wildlife catches much of the popular press (photographs of seals caught in nets, fish tangled in 6-pack rings), potentially entangling debris is not that common. Ingestible items, however, are extremely abundant and pose a serious potential threat to wildlife. Apparently much of what becomes fragments is the wide variety of foam products common in coastal settings (coolers and the like). Foam is easily broken apart by wind and waves, generating a profusion of fragments.

Cape Cod has found significant numbers of tampon applicators ("beach whistles") and q-tip straws, apparently arriving by way of sewage disposal from Boston. If efforts to curtail pollution in Boston Harbor continue, such debris on CACO should decline. Few other parks showed much evidence of sewer-related wastes.

Some Accomplishments

In the middle of this project, it has become obvious that we are a long way from a complete understanding or delineation of the marine debris problem. We can, however, claim several accomplishments.

We have documented, for the first time, the continuous accumulation of marine debris on NPS beaches in all major regions of the United States. We know that plastics overwhelmingly dominate the debris loads deposited on beaches. We have recorded the wide variability in debris deposition and have begun to identify certain common items potentially useful as debris indicators. We have begun to sort out some of the sources of marine debris, though our conclusions still are very broad. We have successfully involved NPS employees from several sources and a wide variety of volunteers in a long-term effort, and we have shown the value of using NPS units as educational centers for the marine debris issue.

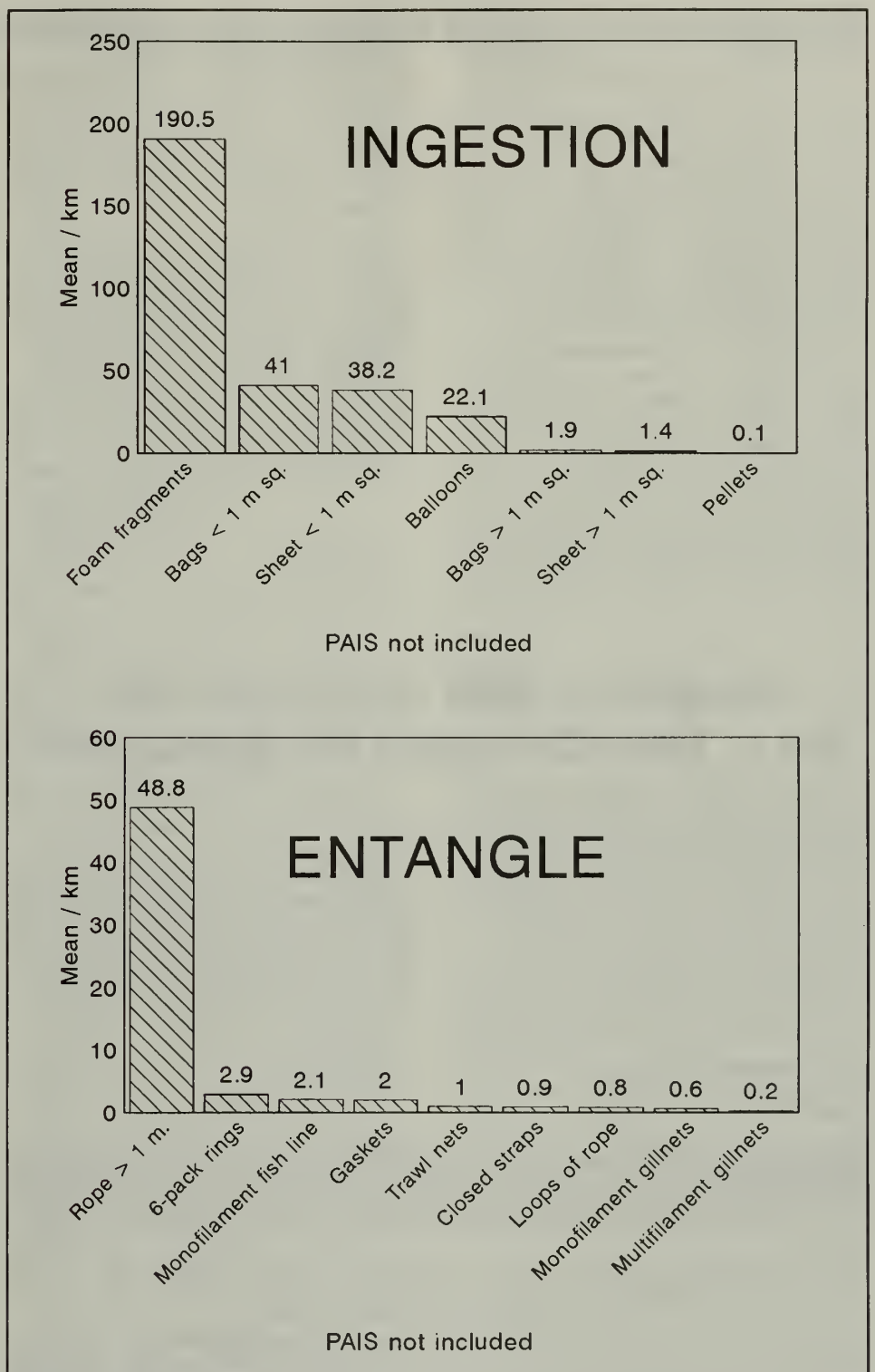

Figure 2. *Mean number/km of ingestion and entanglement related plastic debris items found at the seven NPS marine debris sample sites.*

Dr. Cole is Data Management Coordinator for the joint NPS-NMFS program and an assistant professor at Nova Univ. Oceanographic Center in Dania, FL.

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National Academy Report on NPS Science Released

The National Research Council of the National Academy of Sciences released its long-awaited report entitled "Science and the National Parks" at a Washington, DC press conference on Aug. 19, 1992. The Council summarized its report with the following statement, "*Science and the National Parks* is a critical assessment of the problems hampering the current Park Service science program, providing strong recommendations to help the agency establish a true mandate for science, create separate funding and autonomy for the program, and enhance its credibility and quality."

The report outlines 10 major recommendations for the Service to improve its science program, as follows: 1) seek legislation establishing explicit legislative authority for an NPS science program, 2) create an independent research program where all scientists are supervised by scientists, 3) seek a strategic funding increase for science, 4) develop an independent line item in the NPS budget for the science program, 5) establish a Chief Scientist position and recruit a national stature scientist for the position, 6) establish a basic resources information system, 7) establish a competitive grants program, 8) establish an external, high-level Science Advisory Board reporting to the Director, 9) establish a "parks for science" program, and 10) provide for more involvement of researchers in resource management planning.

Asst. Secty. Mike Hayden, Dir. James Ridenour, and Assoc. Dir. Gene Hester jointly hosted a well-attended press conference on August 19 and gave enthusiastic initial responses to the report. Director Ridenour has assigned Dr. Hester to work with Regional Directors Stan Albright and Bob Baker in appointing a working group of senior superintendents to assist them in formulating a series of action items that will help the Service accomplish the recommendations of the National Research Council report. This group began work in early September to accomplish their assignment.

***Denny Fenn**, Deputy Director*
NPS Natural Resources
Washington, DC

Nadkarni Still 'Up in the Air' As a Tree Canopy Life Specialist

It was way back in 1981, when ***Park Science*** was still ***Pacific Park Science***, that an article on rainforest canopy research at Olympic NP appeared under the by-line of Nalini M. Nadkarni. Two photos of this athletic young lady accompanied the story – showing the author's techniques, with ropes, harness, and Jumar ascenders, in the Hoh rainforest at Olympic.

Twelve years later, Nadkarni appears as the likely heroine of a *New York Times News Service* article by Carol Kaesuk Yoon entitled "Layers of Life." It describes a miniature world of animals and insects that exploit the large bromeliads (members of the pineapple family) that flourish in the canopy high above the jungle floor. Visitors by air include species of bats, wasps, butterflies, and birds, that sip from the rainwater pools or tanks stored deep inside the bromeliad's centerpiece – a tight rosette of leaves. Poison-dart frogs – with flattened bodies and spindly legs perfect for maneuvering through the bromeliad's leaves – bathe, hunt, and raise their young in the pools.

Bromeliads also are home to other small animals, including many yet-unnamed species of beetles and ants, some of them so tree-loving their feet never touch earth.

Less appealing but important are the tank's many worms, microbes and protozoans with Bromeliad addresses. Examination of these plants has yielded up to 300 different species. "If you take a bromeliad and plunge it out into a petri dish and then look under a dissecting scope, it's just a zoo," Nadkarni said.

Nadkarni now is a biology professor at The Evergreen State College in Olympia. She has worked in the Monteverde Cloud Forest Reserve in Costa Rica, and says it's "exciting to get to the plants in this upper part of the forest that nobody knows anything about."

David Benzing, a biology professor at Oberlin College, quoted in the same article, says that "these bromeliad tanks are providing a major resource for life in the canopy ... Wet forest canopy probably is the most species-rich of all the terrestrial communities in the world, and bromeliads are really a pivotal part of the whole system."

Bromeliads get all their water from clouds and fogs and from rainwater they manage to store in their tanks. As for nutrients, they foster the generation of their own fertilizer by means of a happy mutualism – the animals swimming in their tanks excrete wastes, while bacteria and insects help decompose and digest leaves and dead bodies that have fallen into the water. All in all, a rich organic soup.

Scientists have found that the bromeliad then feeds out of its own leafy tureen, using specialized hairs to strain out what it needs. These hairs, called trichomes, can grow on the outer leaves as well, enabling the plant to gather moisture from the forest's humid air.

Tree-dwelling ants leave trails leading out from the edges of the bromeliads where they make their nests in the dry shade of the older, outer leaves. Some ant species are so fond of bromeliads that when they build their huge mound nests in the trees, they plant their own bromeliad seeds.

Certain species of the aforementioned poison-dart frog have been seen *only* in bromeliads. Researchers have tracked mother frogs hopping from bromeliad to bromeliad, visiting each nursery pool where they have left a tadpole or two, lowering themselves into the pools to feed their offspring nutritious meals of unfertilized eggs.

Other plants also reside within the bromeliads ... from algae to tiny predacious plants. The insectivorous plants deep in the pools are hard to spot, Benzing said, except when their blooms jut through the surface of the water as they flower. When small unsuspecting insects swim by the plant, they trigger a bladder which pops open, sucking in the nearby water and usually the prey.

These arboreal gardens, of which there are 2,000 to 3,000 species, are so rich that in a single Costa Rica tree the air plants weighed in at more than 300 pounds.

Wolf Answers: A Second Digest

In response to four questions posed in 1988 by the Senate-House Interior Appropriations Conference Committee, Yellowstone NP researchers prepared two publications: *Wolves for Yellowstone? Vol. I, Executive Summary, and Vol. II, Research and Analysis*, more than 600 pages, submitted to Congress in May 1990. *Wolves for Yellowstone? Vol. II, Research and Analysis* is available from the Yellowstone Assn., PO Box 117, Yellowstone NP, WY 82190 for $16.30, postage paid. An executive summary of the report, Vol. I, is available for $4.20. *Yellowstone Wolf Questions*, an 11-page digest of *Wolves for Yellowstone? Vol. II*, summarizes that information and is available upon request from the Superintendent, PO Box 168, Yellowston NP, WY 82190.

The four questions that necessitated these publications were: (1) would wolves be controlled in and out of the park, (2) how would wolves affect their prey in the park and big game hunting in areas around the park, (3) how would wolves affect grizzly bears, and (4) how would wolf recovery zones be laid out?

More questions remained, so funding for further study was made available in 1989. In 1990, Congress directed the Interior Secretary to appoint a Wolf Management Committee "to develop a wolf reintroduction and management plan for Yellowstone NP and the Central Idaho Wilderness Area." The Committee's recommendations went to Congress in May 1991. Later that year, Congress directed that an environmental impact statement be prepared on reintroduction of wolves to Yellowstone NP and Central Idaho, the draft to be completed by May 1993. *Wolves for Yellowstone? Vol. III, Executive Summary*, and *Vol. IV, Research and Analysis*, were submitted to Congress in July 1992. Those 1992 reports present results of studies completed since Vols. I and II were produced. They contain 18 chapters on results of the scientific studies. They do not represent the NPS or USFWS positions, but are responses to information requested by Congress.

A 16-page summary of Vol. IV (750 pp) has been compiled by Norm Bishop, research interpretive specialist, Yellowstone NP, entitled *Yellowstone Wolf Answers – A Second Digest*, and is available from the PO Box 168 address in Yellowstone NP.

mab notes

A **biosphere reserve managers meeting** is planned, tentatively for December somewhere in mid-continent. This meeting was recommended by the drafting committee for the biosphere reserve action plan to help finalize this document, and was approved by the U.S. MAB National Committee at its July meeting. The managers will review plans and discuss priorities and coordination of the biosphere reserve program.

This is the first BR managers meeting since the 1984 meeting at Great Smoky Mountains NP. That one, attended primarily by NPS managers, generated considerable enthusiasm and numerous recommendations for the BR program. This year's meeting is expected to provide a similar boost and have wider representation.

The National Committee also approved funding of a number of **research projects**. One was the core program of the High Latitude Ecosystems Directorate – a study comparing caribou management systems in western Alaska and north-central Canada. Completion of the core program of the Temperate Ecosystems Directorate – a comparative study of land use patterns and their ecological effects in the Olympic and Southern Appalachian biosphere reserves – also was approved, along with two projects complementary to the latter on water quality and computer integration of interdisciplinary research for application in land use assessment.

Five additional projects were funded: (1) community involvement in management decision making for the Porcupine caribou herd; (2) long-term sustainability of Atlantic white cedar swamps in the Pinelands BR; (3) optimal design of marine reserves: ecology and economics (with testing of the design approach at Channel Islands NP); (4) social-ecological interaction in land use decisions in two western Oregon drainage basins; and (5) sustainable forestry at Sian Ka'an Biosphere Reserve, Mexico (including effects on neotropical migrants and other birds). The U.S. MAB budget exceeded $1 million for the first time in FY 1992.

Two regions are receiving new MAB-related attention. A feasibility study with interagency funding will examine the linking of BRs with other areas in the **Colorado Rockies** to address regional resource issues. The Nature Conservancy has the lead on this study. Land use changes in the **western Sonoran Desert border area** will be the subject of a "regional forum" Oct. 22-25 at Ajo, AZ. Organized by the Sonoran Institute and the Lincoln Institute of Land Policy, this meeting continues the dialog on regional resource concerns begun in the late 1980s by Carlos Nagel under MAB auspices.

The image people have of the biosphere reserve is still varied and often does not match the MAB program's vision. This is revealed in preliminary **results of a survey** conducted by Bill Gregg, NPS MAB Coordinator, and Erica Serabian. Only about a third of U.S. BRs, including NPS and other sites, have responded so far, but certain views can be distinguished. BR designation often is considered a recognition of site significance rather than a framework for cooperation. Also, some managers (not NPS) see their BRs primarily as research sites, operating largely in isolation from their neighbors.

A more balanced view – that of the BR as a place where research and cooperation both are conducted in the service of regional needs – tends to be held by managers of the more recently designated biosphere reserves and those with a history of BR-related cooperation. Perhaps the survey also tells us that the situation and history of each BR are unique, and may favor certain BR functions over others. For some sites, evolution toward a full-fledged biosphere reserve may be naturally slow.

Napier Shelton
NPS Washington Office

Stottlemyer, Doren and Wade Receive Awards

Robert Stottlemyer, Water Resources Division, WASO, was named recipient of the Director's natural resource-related Award for Research; Robert Doren, Everglades NP was selected for the natural resource Management Award, and Bill Wade, Shenandoah NP, was named Superintendent of the Year for natural resource stewardship.

Stottlemyer's research "contributes to understanding specific park ecosystems, especially in Alaska and Midwest parks, and to the fields of forest vegetation, nutrient dynamics, biogeochemical cycling, and global climate change," according to the award.Doren's selection was based on his work on the exotic plant management/wetlands rehab project in the Hole-in-the-Donut area of Everglades, its subsequent identification of the area as a mitigation bank, and its receipt of a general permit for additional restoration work. His work in exotic plant management has been recognized by his election to the chairmanship of the Exotic Pest Plant Council.

Wade was recognized for his commitment to resource management and scientific data, as demonstrated by his use of base funds to create and fund a separate resource division, professional positions, and research. His support has provided the park with the capability to compete favorably for other fundings as well. Shenandoah has been chosen as a pilot monitoring park by the Servicewide I&M Program.

letters

To the Editor:

In June (23-25) a meeting entitled "Giant Sequoias: Their Place in the Ecosystem and Society" was held in Visalia, Calif. The National Park Service played an extremely important role in the development and presentation of the agenda. Many of the talks were presented either by NPS folks or by university scientists who have been funded by NPS. It was obvious from the presentations that we were far ahead of the other agencies in understanding the factors influencing sequoia mixed conifer forest dynamics.

This conference was called by the Forest Service largely in response to the enormous protests from environmentalists over the logging of all but the monarch sequoias within USFS groves. It was a politically hot session that culminated in mid-July with President Bush's visit to the nearby Sequoia National Forest (Sandra Key is the new supervisor there!) to endorse the concept of long term protection of the groves. Nevertheless, legislation continues to wind its way through Congress that would actually create a National Monument or similar status for the USFS groves.

The 13 presentations given either by NPS scientists or NPS-funded researchers were part of the following panels: Natural Values, Public Values,and Public Perceptions; Natural Perspectives, Genetic Characteristics, and Ecological Considerations; Giant Sequoia in a Disturbance-Driven Environment; Management Strategies; and Influences on Grove Development. Sequoia and Kings Canyon NP (SEKI) Supt. Thomas Ritter participated in the windup panel on Symposium Results: Views from the Agency Leadership.

I am also extremely proud of the involvement of the SEKI and Yosemite NP staff and cooperators at the Aug. 9-14 meeting in Honolulu of the Ecological Society of America. I am especially pleased to see NPS science starting to become more actively involved in such meetings.

David J. Parsons, *Research Scientist*
Sequoia and Kings Canyon NPs

meetings of interest

1992

Oct. 27-30, 19TH ANNUAL NATURAL AREAS CONFERENCE and 14TH ANNUAL MEETING OF THE NATURAL AREAS ASSN., at U/IN campus, Bloomington. Contact: Division of Nature Preserves, U/IN, 402 W. Washington St., Rm. W 267, Indianapolis 46204; (317) 232-4052.

Oct. 27-30, REDISCOVERING AMERICA: Natural Areas in the 1990s, the 14th Annual Natural Areas Conference, at Indiana Memorial Union, Indiana University, Bloomington. Contact: Indiana U Conf. Bureau, IMU Room 677, Bloomington, IN 47405; (812) 855-6451.

Nov. 16-20, PARTNERS IN STEWARDSHIP, the George Wright Society Conference on Research and Resource Management in Natural and Cultural Parks and Reserves, Jacksonville, FL. Contacts: John Donahue, NPS, 18th & C Sts NW, Washington, DC 20240 (202) 208-4274 and Harry Butowsky, NPS, PO Box 37127, DC 20013-7127 (202) 343-8155.

1993

April 18-23, WESTERN REGION INTEGRATED CULTURAL & NATURAL RESOURCES WORKSHOP, at Furnace Creek Ranch, Death Valley National Monument. Western Regional Office contacts: Jonathan Bayless, Div. of Park Historic Preservation, (415)744-3968, and Gene Wehunt, Div. of Natural Resources and Research, (415) 744-3957. The goal is to strengthen both programs in Western Region parks by promoting closer ties between the subject area professionals and development of interdisciplinary approaches to problem solving.

Mar. 24-27. EIGHTH ANNUAL U.S. LANDSCAPE ECOLOGY SYMPOSIUM, "Pattern and Process in Landscape Ecology," at Oak Ridge National Lab in Oak Ridge, TN. Nov. 15 deadline for abstracts. Contact: Dr. Monica G. Turner, Envir. Sciences Div., Oak Ridge National Lab, PO Box 2008, Oak Ridge, TN 37831-6038; (615) 574-8282.

Kemp's Ridley Research Continues

By Donna Shaver

Kemp's ridley sea turtle (*Lepidochelys kempi*) is the most endangered sea turtle species in the world; only about 400 nesting females remain in the population. In the last two decades, Padre Island National Seashore (PAIS) has participated in, and established, several projects to conserve, restore, and study this critically endangered species. Park programs have encompassed all life stages of Kemp's ridley turtles, from incubation of eggs to study and protection of adults.

Efforts to Establish a Secondary Breeding Colony

In 1978, agencies from the U.S. federal government, State of Texas, and Republic of Mexico began a cooperative program to restore and enhance the Kemp's ridley sea turtle population. Nearly all nesting by this species occurs along a 16 mile stretch of beach near the village of Rancho Nuevo, Tamaulipas, Mexico. However, sporadic nesting has been reported from Corpus Christi, Texas to Veracruz, Mexico. A portion of the restoration program was a 10-year experimental attempt to establish a secondary breeding colony of this species at PAIS through "imprinting" (Fletcher 1982, Shaver 1990).

During each summer, from 1978-1988, approximately 2,000 Kemp's ridley eggs were collected from Rancho Nuevo and shipped to the park for incubation and a large quantity of data, never previously collected for this species, was amassed (Shaver et al. 1989, Shaver and Chaney 1989). Of the 22,507 eggs received, 17,358 (77.1%) hatched (Shaver 1989a, 1990) and 15,875 hatchlings subsequently were shipped to the National Marine Fisheries Service Lab in Galveston, Texas for 9 to 11 months of captive rearing (termed "head-starting"). Overall, 13,454 of the head-started yearlings, experimentally imprinted to Padre Island, were released into the Gulf of Mexico.

Beach Patrols and Egg Incubation

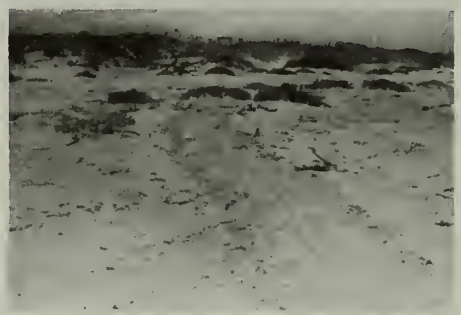
To date, no turtles released from this project have been found nesting at PAIS or elsewhere. However, it is unknown how many survived after release. Additionally, it is uncertain whether any have attained adulthood yet, since at least 11-12 years may be required for females of this species to attain the minimum nesting size (Zug 1990).

A pair of mating Kemp's ridley sea turtles was sighted within the Mansfield Channel, located at the southern end of the park, on June 3, 1991 (Shaver 1992). This was the first documented observation of mating by this species in Texas waters. Unfortunately, the turtles could not be identified as either wild or head-started and no nests were found subsequent to the mating.

In an attempt to identify whether Kemp's ridleys are returning to nest at PAIS, seasonal beach patrols for nesting sea turtles, tracks, nests, and hatchlings were initiated in 1986. From mid-April through August, park and other local beaches are patrolled from 3-7 days per week. All-terrain vehicles, 4-wheel drive trucks, and surplus military vehicles are used to conduct these rigorous patrols. With the assistance of numerous dedicated volunteers, park staff patrol a 70-mile stretch of beachfront daily, with a total of approximately 6,500 patrol miles being logged each summer.

Beach patrollers also attempt to identify and protect nests laid by sea turtles that are not part of the restoration project. Kemp's ridley, loggerhead, and green sea turtles nest in small numbers along the Texas coast. Twelve confirmed nests were found from 1979-1992, most at PAIS (Shaver 1989b, 1990, 1991). In fact, during the last decade, more Kemp's ridley nests have been located at PAIS than on any other beach in the United States. Because of the level of park personnel expertise in incubating sea turtle eggs, PAIS incubated or monitored 11 of the 12 nests laid along the Texas coast and all sea turtle eggs laid by captive turtles held in Texas.

Kemp's ridley sea turtle hatchling *being fed in the PAIS rehabilitation facility.*



Green sea turtle tracks *shown here were found at Padre Island NS on July 14, 1992.*

Sean Baker, Biological Technician, *conducts a patrol for nesting sea turtles, tracks, and stranded hatchlings.*

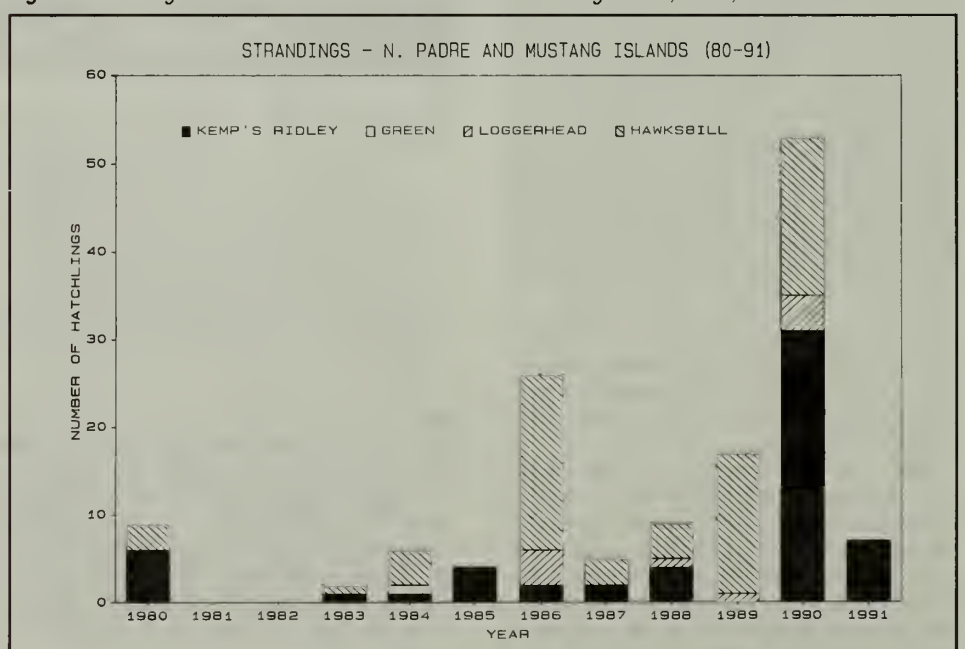
Strandings and Rehabilitation

In 1980, the Sea Turtle Stranding and Salvage Network was established to document, protect, and study sea turtles washed ashore on U.S. beaches. Since the inception of this network, the park has taken an active role and maintained records for all strandings documented on Texas shores.

The park recently took the lead in efforts to detect and protect sea turtle hatchlings stranded on local beaches. Since 1980, more hatchling sea turtles have been found stranded along the beaches of North Padre and Mustang islands than any other area in Texas. Significantly more were located during the summer of 1990 than during any previous summer from 1980-1989 (Shaver 1991) (Fig. 1). Forty (including 23 Kemp's ridley) hatchlings were found alive, but most were weak, injured, and in need of immediate care and stabilization. Beginning in 1990, the park instituted programs to address the three following concerns related to stranded hatchlings: (1) detection; (2) care and rehabilitation, and (3) study and determination of age/origin.

Stranded hatchlings are extremely small and difficult to detect. Ongoing beach patrols have been modified to facilitate location of these animals. During the hatchling stranding season, patrols are conducted at slower speeds and patrol efforts are concentrated in areas of known, previous hatchling strandings. Public education programs, ongoing to solicit public assistance with reporting of nesting turtles and tracks, have been modified to include messages about reporting stranded hatchlings.

Figure 1. *Hatchling sea turtles stranded on North Padre and Mustang Islands, Texas, 1980-1991.*



at Padre Island National Seashore

Unfortunately, in 1990, there was no suitable local facility available where the hatchlings could be taken for stabilization and rehabilitation. After coordination with John Miller (Chief, Resource Management PAIS) in early 1991, EXXON Corporation, USA donated funding for construction of a hatchling rehab facility at the park. This is the first in the world designed specifically for the rehabilitation of stranded Kemp's ridley sea turtle hatchlings. It has the capacity to hold 70 turtles, each in an individual 20 gallon aquarium. Local veterinarians assist with care of the hatchlings and those successfully rehabilitated are released into the Gulf of Mexico.

Park staff attempt to determine whether the hatchlings found washed ashore on local beaches emerged from undetected nests laid on south Texas beaches. All stranded hatchlings are measured and examined externally. Additionally, dead individuals are necropsied and gonads are removed for histological sex determination. We believe that some of the loggerhead and Kemp's ridley hatchlings found during the last decade may have emerged from nests laid on south Texas beaches. However, most of the larger Kemp's ridley and all of the hawksbill hatchlings probably originated elsewhere.

Future Program Efforts

Since 1978, the park has been involved in a continuum of research and conservation measures to help save the Kemp's ridley from extinction. By increasing the chances of survivorship of individual Kemp's ridley turtles, park efforts ultimately may aid the overall recovery of the species.

The NPS now is focusing efforts for this species on attempts to locate and protect nesting females (wild and head-started), nests, and stranded hatchlings. Staff members at PAIS are conducting extensive beach patrol and public education programs, both of which have been given high priority in the recently completed Kemp's Ridley Sea Turtle Recovery Plan. As directed by the Recovery Plan, Endangered Species Act, NPS mandates, and PAIS Sea Turtle Management Plan, these programs will continue for the foreseeable future.

Shaver is Supervisory Natural Resource Management Specialist at Padre Island National Seashore

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Mount Rainier Named A "Decade Volcano"

A science plan for organizing the research needed to evaluate the hazards associated with Mount Rainier and for developing ways to communicate this risk assessment as a basis for appropriate planning is the goal of an introductory workshop held Sept. 18-20 at the University of Washington. The workshop was organized under the auspices of the National Academy of Sciences' U.S. Geodynamics Committee in cooperation with the Academy's Board on Natural Disasters, and was co-hosted by the USGS and U/WA. The University hopes to establish an interdisciplinary Volcano Studies Center.

Mount Rainier, the highest (4392m) volcano in the Cascade Range, towers over a human population of more than 2.5 million in the Seattle-Tacoma metropolitan area. Its drainage system via the Columbia River potentially impacts another half million residents of southwestern Washington and northwestern Oregon. In terms of its potential for magma-water interaction and sector collapse and for major eruptions – or debris flows even without eruption, Rainier is the most hazardous volcano in the Cascades. Although it poses significant dangers and economic threats to the region, it has received little study.

In 1989 the International Association of Volcanology and Chemistry of the Earth's Interior (IAVCEI) established a Task Group for the International Decade for Natural Disaster Reduction. The Task Group conceived the idea of selecting several volcanoes for focused study in the next decade as "Decade Volcano Demonstration Projects," established criteria for a "Decade Volcano," and solicited nominations. The IAVCEI accepted nominations of 7 volcanoes in developing countries and 2 in the U.S. – Mount Rainier and Mauna Loa.

Workshop organizers hope to publish the science plan by early 1993. For additional information contact Barbara Samora, Resource Management Specialist, Mount Rainier NP, Tahoma Woods, Star Route, Ashford, WA 98304-9751; (206) 569-2211.

Toward an NPS "Virtual Library" Supporting Research Servicewide

By Diane Mallos

Forget your notion of "the library" as just a neatly organized room full of books. Instead, think of the universe of knowledge hidden away in unpublished research reports and field data as well as books, journals, manuscripts, photographs, sound recordings, video tapes, microforms, maps, data in geographic information systems, etc. Then imagine being able to find "the good stuff" or to connect with scientists in the Service or elsewhere in the world – without leaving your own park library!

NPS resources are among the most written about and studied of any in the world. More than 300 libraries in the National Park System house collections ranging in size from a few hundred to tens of thousands of volumes. In addition, most parks contain a wealth of research material that supports the park's mission. As a result, many parks contain unique collections of material that may be found nowhere else.

The current state of all this information could be said to be "available but inaccessible." The Service spends vast quantities of money on research and specialized bibliographies whose benefits are limited because of ineffective dissemination. The excellent work being done at CPSUs frequently is available only at the park or within the Region where the studies are conducted. An expensive result could be duplication of research efforts within the agency. Access to foreign research reports through such networks as Internet also could help parks avoid duplicating research done outside the Service.

Unfortunately these gold mines of resource material remain unorganized and inaccessible due to (1) lack of adequate funding and trained staff at most NPS libraries – only 4 out of the 10 NPS Regions have regional librarians, and (2) the lack of an information network on which to share information within the NPS and internationally.

But there is hope – the hope of sharing NPS and outside research electronically – an NPS "virtual library." The great mass of knowledge held by NPS, other government agencies, and academic and research institutions worldwide could eventually be at the fingertips of NPS personnel, from scientists and resource managers to historical architects and exhibit designers – the whole array of personnel with the need to stay aware of what others are doing in the same or related fields.

The NPS Washington Office's Information and Telecommunications Division is taking this idea very seriously. In addition to setting up the technical workings of a Servicewide electronic communications network (ParkNet), they have hired a professional librarian on the Policy and Planning staff. As that new librarian, I am looking at ways to fully catalog and automate the NPS research resources now hidden in NPS libraries and other repositories.

Library software to make automation of library collections as simple and cost effective as possible is being examined. An NPS link with international networks is being investigated. Information distribution systems used by other federal agencies and various funding strategies also are being studied.

I am eager to hear from scientists, resource managers, park managers, and others regarding these issues. Please send your comments or questions to me, Diane E. Mallos, Library Coordinator, NPS Information and Telecommunications Division, Policy and Planning Staff, PO Box 37127, Washington, DC 20013-7127, or call 202/343-4430. I will be reporting further in ***Park Science*** as this effort develops.

Aircraft Noise Effects Research Literature Emerging

Results of research on the effects of aircraft overflights on park resources and on visitors are becoming available as part of NPS and USFS research conducted in response to Public Law 100-91. The research is being contracted by the NPS Denver Service Center and supervised by the NPS Ranger Activities Division in Washington.

The reports include the following technical literature reviews, which may be of interest to many park areas: *Aircraft Noise Effects on Cultural Resources: Review of Technical Literature; Review of the Effects of Aircraft Overflights on Wildlife;* and *Effect of Aircraft Altitude Upon Sound Levels at the Ground.* Other finished reports describe methodologies for conducting noise research in parks and for surveying park visitors about aircraft noise; they also describe the noise measurement results at Grand Canyon NP and several national forest wildernesses.

Research now is being conducted to determine responses of park visitors to aircraft overflights, responses of air tour passengers, and comparison of measured noise doses to visitor responses at several parks. Computer models are being developed using NPS geographic information system technology to model the noise environment in parks and predict the effects of various mitigation strategies.

We also have our contracts structured in such a way that it is easy for anyone in the NPS to use them for consultation or research regarding any type of noise or aircraft concerns in parks.

For further information on the research, contracts, or publications, contact **Wes Henry, Washington DC, (202) 208-5211 or Rick Ernenwein, Denver, (303) 969-2274.**

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PARK SCIENCE

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USGS and NPS: Science Partners In the Parks

By Dallas Peck
Director, U.S. Geological Survey

This special earth and water science issue of *Park Science* is just the latest display of the long-term partnership between the U.S. Geological Survey and the National Park Service. Actually, the partnership between us, between the national parks and the earth, water, and mapping sciences, began long before there was a National Park Service or a U.S. Geological Survey.

That early partnership was based very much on exploration and discovery. The beauty and exciting geology of the landscape were natural magnets that drew some of the nation's first geologists to map, study, and defend the Crown Jewels before they were added to the protected public domain.

Two of these early explorers and defenders of the not-yet national parks, Clarence King in Yosemite and John Wesley Powell in the Grand Canyon, carried out scientific investigations that would help build careers that made them the first and second directors of the USGS.

Our century-old partnership has grown steadily. Since the USGS was founded in 1879, hundreds if not thousands of USGS scientists have worked or studied in national parks at some time during their careers. I am personally proud to be part of that tradition. Several decades ago I worked for 2 years at the USGS Hawaiian Volcano Observatory in Hawaii Volcanoes NP, monitoring eruptions of Kalauea Volcano. Someday, when my turn as Director of USGS is done, I hope to return to my field studies of Sierra Nevada granites in Yosemite NP.

Why have earth scientists spent so much time in the national parks? Because that is where the earth has revealed some of its best science. To study volcanoes, one must go to volcano country. To study granites, one heads for granite mountains. Scientists are far from immune to the beauty of the parks, but what draws us is the challenge of describing and exploring the forces and processes that built and continue to shape volcanic islands and mountain chains.

We could get into a chicken and egg argument: which came first, the beauty or the science? Was it beauty or science that drew the first explorers, that made the winning arguments to convince the public, that laid the groundwork for establishment of the first parks?

Continued on back cover

Tracking Dinosaurs in Virginia and Arizona--USGS Scientist Ron Litwin (left) discusses casts of dinosaur tracks with Dallas Peck, Director of the U.S. Geological Survey, and Eugene Hester, Assoc. Dir. for Natural Resources of the NPS (right). The dinosaur footprints, found during a 1991 civil engineering project in Manassas, VA, are typical of those found recently throughout the Culpeper Basin. The basin that lies between Frederick MD and Culpeper, VA is the same geologic age as Petrified Forest NP in Arizona. Cooperative research by USGS and NPS scientists on both sites is not only improving the understanding of dinosaur behavior, but also providing a clearer picture of weather and habitat conditions between 225 and 150 million years ago.

Hester and Peck unveiled the dinosaur tracks as part of a new display at the USGS National Center, Reston, VA. More than 10,000 people have viewed the tracks since the display opened in spring 1992.

USGS geologists found fossil pollen and spores from evergreen trees, mosses, ferns, horsetail rushes and other plant life in rock layers above and below the track site. These microscopic fossils are from the Early Norian part of the Triassic Period, approximately 215 million years ago. The group of pollen and spore fossils is nearly identical to those studied in rocks exposed in the Petrified Forest NP.

USGS and NPS scientists have collaborated on many geologic problems, whether the geologic history of Crater Lake, thermal changes of geysers at Yellowstone volcanic field, or the age of artifacts found in glacial deposits in Alaska. Members of both bureaus have much to learn from one another about the natural setting of our national parks, which comprise nearly a quarter of all land in the western United States.

PARK SCIENCE

NATIONAL PARK SERVICE

WINTER 1993

A report to park managers of recent and on-gong research in parks with emphasis on its implications for planning and management

ARTICLES

DEPARTMENTS

editorial

The 7th Annual Conference on Research and Resource Management in Parks and on Public Lands (Nov. 16-20, 1992 in Jacksonville, FL) spoke eloquently in the tongues of many public and private agencies to the increasingly complex nature of resource management today and to the urgent need for scientists and historians to *communicate* their findings....not just to one another, but to resource managers and to the public.

"Partners in Stewardship," the conference theme, was intended to intensify communication among scientists, historians, and the managers of natural and cultural resources. Speaker after speaker testified to the mounting complexity of air and water quality, the dwindling biological diversity, the uncertain consequences of global climate change, and the rapidly changing public perception of what constitutes recreation in public lands. A parade of spokespersons from NPS, USFS, USFWS, the Bureaus of Reclamation and Land Management, and from "watchdog" groups reminded the conference of the social, political, and economic factors that bear heavily on management of natural and cultural resources.

In the course of 5 days of plenary and concurrent sessions, (and some initial confusion over conference objectives) an emergent theme was the dawn of a third era in the evolution of protected areas: from preservation (John Muir) and conservation (Gifford Pinchot) to **sustainability** (the consistent new note throughout all areas of the conference.) The sharing of vision and experience added up to "staying ahead of the curve" of rapid change in our culture and recognition of how that change is writing itself on the face of our land and waters. In case after case, it became apparent that the implications of research findings must be communicated to the public users of protected areas, for out of the public's perceptions grow the public's expectations--and these are what, inevitably, **will be served**.

Gene Hester (NPS/AD for Natural Resources) described the binary vision (natural and cultural) currently being focused through such activities as GIS, I&M, and Resource Management Plans. He cited both the Vail conference (October 1991) and the NAS Report (August 1992) as having "helped us recognize two main questions: Do you know what your problems are? and Do you know what you're going to do about them?" The answers, he suggested, require the very best of both natural and social sciences.

Dr. Hester alluded to the 5-Year Strategic Plan, designed as implementation of the Vail and NAS agendas (see Denny Fenn article, p.17 this issue) and stressed the necessity of on-going linkage among scientists, historians, and resource managers.

A booklet of conference abstracts is available in limited quantities from the George Wright Society, PO Box 65, Hancock, MI 49930. Selected papers from the conference will be published in 1993.

ISSN-0735-9462

Channel Margin and Eddy Bar Deposition Along the Colorado River in Grand Canyon NP

by J. Dungan Smith and Edmund D. Andrews

The characteristics of biologically important, riverine environments depend directly on the nature of flow and sediment transport in the river channel, and on the mechanisms and rates of exchange of sediment between the deposits near the banks and the channel. Owing to the sensitivity of the riparian habitat to riverine processes, alteration of the river discharge or the sediment input can have a substantial impact on this important ecological zone. Consequently, the choice of dam release regimes should be guided by a scientifically founded, environmentally sensitive management plan. Such a plan should be based on a precise knowledge of the dominant flow and sediment transport processes in the river and on a comprehensive understanding of the interplay of these physical processes with the salient biological and chemical features of the riparian zone. Since 1983, the Glen Canyon Environmental Studies Office of the U.S. Bureau of Reclamation has supported a comprehensive set of investigations to determine the effects of operational flow releases from Glen Canyon Dam on the riparian and aquatic resources of the Colorado River. Many individuals representing several federal and state agencies have contributed to this effort. Research concerning the downstream changes in flow characteristics under various discharge regimes, the associated transport of sediment, and changes in important channel deposits has been the object of a cooperative effort by the NPS and the USGS. The goal of this research is to develop a comprehensive model that can be used to study the response of the riparian ecosystem of Grand Canyon NV to alternative flow regimes.

Canyon Geomorphology

The Grand Canyon began to form about 8-10 million years ago as the Colorado River cut deeply into the rising Colorado Plateau. As a consequence of the deep channel incision, debris from rock falls (talus) and bedrock, rather than fluvial sediment, are the most common bank materials. Furthermore, tributary channels are short and steep. Occasional debris flows and large floods in these tributaries add coarse material to the main channel in the form of deposits that partially block the channel. These constrictions cause backwater pools on the upstream sides, rapids over the top, and the cutting of deep pools into bedrock downstream of the debris deposits. Both the upstream and the downstream pools are depositional sites at moderate river flow, but the downstream pools become active zones of scour under prolonged periods of extreme discharge. Since closure of the Glen Canyon Dam in 1963, the peak flows have been too small to move the coarsest material.

The large load of suspended sand and irregular width and depth of the Colorado River results in a channel with numerous local areas of erosion and deposition. Connected bands of sand along the channel edge are called "channel margin deposits". In the Grand Canyon, these now provide the substrate for narrow zones of dense vegetation, which, in turn, form habitat for a wide variety of terrestrial organisms. Larger accumulations of sediment are deposited at the downstream ends of rapids where abrupt increases in channel width cause flow separation and hence, stream edge recirculation zones (called eddies). In these eddies the near-bank current is in the up-river direction, and the prolonged retention of sediment laden water entering them from the main channel results in rapid deposition of the suspended sand and silt. "Eddy bars" created beneath recirculation zones during periods of high flow and exposed when the river stage falls can be quite large and are a more suitable substrate for riparian vegetation than debris fans, (see Fig. 1).

Figure 1. An eddy bar deposit downstream from Nankoweap Canyon. Such deposits are comonly the only suitable camping sites for river trips. This bar was deposited by large discharges during 1983-85, and now (1992) thickly vegetated.

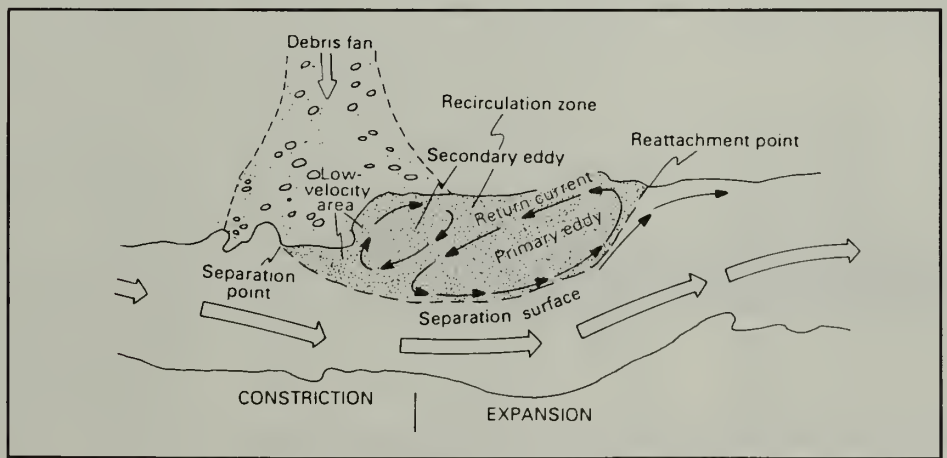

Figure 2. Flow pattern in a typical recirculation zone, *(figure from Schmidt and Graf, 1990)*

Flow and Sediment Transport

Daily, monthly and annual flows of the regulated Colorado River are very different from those of its free flowing predecessor. These changes in flow patterns have had a significant effect on the downstream environment. Prior to the construction of Glen Canyon Dam, the Colorado River through the Grand Canyon had an average annual discharge peak of more than 90,000 cubic feet per second (cfs) and, except during major flash floods in tributaries, discharge and river stage changed slowly from day-to-day. Operation of Glen Canyon Dam has reduced the maximum annual peak discharge to less than 33,000 cfs in most years, but has greatly increased the daily range of discharge. Depending on electrical power demand, daily fluctuations of the river stage can reach 14 feet. This change from seasonal to daily variation has had a significant effect on the riparian environment. In addition, the main supply of sediment to this reach of the Colorado River is now deposited behind Glen Canyon Dam. The annual predam sediment flux past the mouth of Bright Angel Creek (near Phantom Ranch) was 95 million tons of sand, silt and clay. Today only about 11 million tons per year of sediment, on average, are supplied annually by tributaries to the Colorado River downstream from Glen Canyon Dam. Although these changes in river discharge and sediment input are large, Glen Canyon Dam still can be operated to maintain critical river resources, including

Continued on page 4

Coastal Geology and National Parklands:

Robert B. Halley and Richard W. Curry

More than 50 percent of all Americans live within 50 miles of our Nation's oceans or the Great Lakes. As population increases along the coasts, so does pressure on coastal resources. More than a dozen National Parks and the many national seashore areas share common concerns with the USGS Coastal Geology Program about the impacts of man and nature on these sensitive areas. Coastal environments are typically in a continual process of change. This change may be so slow as to be imperceptible on the human scale, becoming apparent only over periods of geologic time. Or, coastal change may be catastrophic and as violent as recently exemplified by Hurricane Andrew. Nature presents the challenge to humankind of incorporating these processes of change into plans for conservation and preservation.

Geological processes play important roles in coastal evolution and ecosystems. In many areas, coastal erosion is the most visible coastal process. Erosion presents a hazard along developed coasts and is a process which modifies many undeveloped coastal areas. Less apparent, but no less important, pollutants associated with fine-grained sediments travel through coastal systems to accumulate in low energy areas such as coastal swamps and lagoon floors. Coastal wetlands, important nurseries for marine and terrestrial wildlife, are altered by natural sedimentation and infilling, by sea-level change and by erosion of protective barrier islands. A thorough understanding of these coastal processes is required to accurately predict their future effects and to evaluate the success of management plans.

Issues concerning coastal geology and pollution merge in peninsular Florida where urban and agricultural demands impact the Everglades and Biscayne NPs. In Florida, as well as in many other states, the USGS Coastal Program and the NPS have obvious common ground for coastal research. Additionally, because of its tropical climate, coastal issues in south Florida have counterparts in National Park areas of Puerto Rico, U.S. Virgin Islands, Guam, and other tropical regions associated with the United States.

One example of coastal research sponsored jointly by the USGS and NPS examines the history of runoff in southeastern Florida. Runoff is an important environmental variable in coastal systems. In south Florida, runoff strongly influences the salinity of nearshore environments. Natural and anthropogenic nutrients are brought to coastal water bodies by runoff. Increasingly, human-made (anthropogenic) pollutants such as heavy metals may also be intro-

Continued on page 5

CHANNEL MARGIN. . .CONT'D FROM PAGE 3

channel margin and eddy bar deposits.

Deposition and Erosion of Eddy Bars

When a river channel widens abruptly, the inertia of the rapidly moving fluid near the center of the channel causes this high velocity core to continue more or less straight downstream, departing or "separating" from the abruptly diverging bank. Flattening of the downstream component of the river surface slope, however, also causes the high velocity core to decelerate and spread laterally. Eventually the core of rapidly moving fluid reaches the bank or "reattaches". Adjacent to that bank between the points of separation and reattachment the fluid moves in the upriver direction (recirculates) Figure 2. Typically the high velocity core decelerates at an increasing rate, causing the boundary between the slowly moving fluid in the outer part of the recirculation zone and the more quickly moving fluid at the outer edge of the high velocity core to curve towards the bank. This curvature causes a net outward flow near the river surface and a net inward flow near the bottom, producing an extremely effective trap for suspended sand which travels in higher concentration near the river bed. Once this sand is carried into the recirculation zone where the turbulence levels are substantially lower than in the main channel, it settles to the bottom and moves as bed load, that is, by rolling and hopping along the bottom.

Only during periods of exceptionally high flow is sand carried through the recirculation zone in suspension, and even then most of the material is retained in and deposited beneath the eddy. This process operates on all scales, but small embayments fill rapidly with sediment and the deposits often are washed out again as the stage rises. Such small-scale deposits usually are preserved only when produced by very high-stage events, and preservation is aided substantially when relatively dense stands of vegetation become established between infrequent large floods. The outer edges of these channel margin deposits are eroded by subsequent flows of lower stage, causing cut banks that give the impression of extremely rapid erosion. These channel boundaries, however, are very dynamic and rapid erosion at one range of discharge is often followed by rapid deposition. Conversely, slow erosion often is a consequence of negligible deposition.

Channel margin deposits and eddy bars are eroded by several mechanisms. The most effective of which occurs when flow overtops an upstream obstacle resulting in elimination of the recirculation zone and a return to downstream flow near the bank. This situation usually produces a large local increase in the sediment transport rate and, hence, erosion of the previously deposited material. Sand deposits also can fail and slump into the channel when erosion removes the supporting toe of the sand bar. This mechanism is enhanced by an elevated water table that creates excess pore pressure in the deposit, when river stage falls quickly. Wind erosion of exposed eddy bars also is an effective process degrading these deposits.

The continued presence of high stage channel margin and eddy bar deposits in the Colorado River through Grand Canyon NP depends on their occasional reconstruction during high discharge events. These deposits, in fact, consist of sediment grains for which the downstream movement has been interrupted temporarily. Although a particular sand bar may appear to persist for years or decades, there is a continued exchange of sediment between the deposit and the river. Eddy bar deposits exist where there is sufficient deposition in the long term to replace local erosion. A proper accounting of the complex interplay of processes responsible for bar deposition and maintenance, each occurring at a rate that depends on the flow and available supply of sediment, requires a combination of precise field observations and carefully constructed, fluid dynamic models.

Conclusion

There is a very close relation between the discharge history of a deeply incised river in an arid region, and the riparian environment of that river. Owing to the incision and the need for water in surrounding areas, such rivers are prime candidates for impoundment. Unfortunately, the environmental effects of flow regulation on such rivers can be considerable and until recently these effects have not been carefully assessed when planning dam operations. The Glen Canyon Dam, which discharges into the Marble and Grand Canyons, is an obvious example of a structure that could be managed more efficiently using recently procured scientific knowledge. Extensive research currently being carried out concerning flow, sediment transport, eddy beach deposition and maintenance of riparian habitat in this segment of the Colorado River is producing a sound foundation for environmentally sensitive management of this dam. It is likely that this research will lead to knowledge and operational models that also can be used effectively for river management in other national parks and recreation areas.

Smith and Andrews are with the USGS in Denver, CO.

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duced with runoff. Understanding the history of runoff in Biscayne NP provides valuable evidence of the tolerance of tropical coastal ecosystems to influences from adjacent land areas.

Arguably the greatest anthropogenic impact in south Florida is the modification of its natural hydrogeology by a system of canals, salinity barriers, impoundment dams, water conservation areas, and pumping stations (Klein, 1973). The "drainage" of the Everglades for agricultural use began at the turn of the century. Disastrous floods in 1926 and 1928 prompted continued modification for flood control, as did the 1947 flood which heralded the establishment of the Florida Water Management Districts (Huser, 1989). By the time Everglades Park was established, the opportunity to collect detailed information about the natural state of south Florida hydrogeology had passed. Knowledge of the natural state of south Florida hydrogeology must be reconstructed through historical records, geological records, and modeling efforts.

During the rainy summer and fall, the water table in the Everglades rises above the ground and runoff occurs as sheet flow over topographic low areas along the coast. Prior to this century, most of the flow was to Florida Bay and the Gulf of Mexico. Eastward flow was blocked by a topographic feature known as the Atlantic Coastal Ridge. Most development after 1900 has taken place on the relatively high ground of the ridge which attains elevations of 8 meters above sea level. Drainage of the Everglades was facilitated by dredging canals through the ridge. Many of these canals drain into the Atlantic though Biscayne Bay. During the dry winter months saltwater intrusion is prevented by salinity gates at the canal mouths and by maintaining water levels in the canals from impoundments inland.

Florida groundwater typically contains dissolved soil acids that fluoresce in the visible range when excited by ultraviolet light (Averett and others, 1987). During times of increased runoff from the land, these fluorescent compounds mix with coastal marine waters and are transported to nearshore reefs. There, the soil acids are incorporated into the growing coral skeletons and preserved in the aragonite skeletal matrix. Several species of corals produce annual density variations in their skeletons which, like tree rings, can be used to date skeletal intervals. This science, known as sclerochronology, has shown that some coral species may grow for several centuries (Hudson and others, 1976). and may provide a record of runoff from adjacent land areas based on fluorescence data.

Figure 1 illustrates density and fluorescent images for a coral sample from Biscayne NP. The figure represents a portion of a coral record that spans 117 years. Image analysis of the entire record provides a relative fluorescence record for more than a century shown in Figure 2. The record can be divided into three time periods. The period 1870 - 1920 is characterized by low fluorescence punctuated by occasional years of high fluorescence. This pattern is similar to the pattern of measured rainfall in south Florida and is thought to represent the natural variability of runoff. The years from 1920 to 1955 span the drainage and flood control periods and reflect frequent high runoff years associated with dredging. During the late 1950s and 1960s water management practices were instituted to conserve runoff during the wet season to maintain dry season water levels. This period is recognized in the fluorescence record by the absence of years characterized by high fluorescence from about 1955 to 1987. Coral fluorescence therefore provides a proxy record of runoff into Biscayne NP and a measure of the natural variability in the south Florida hydrogeological system before it was altered.

Coral fluorescence provides a geological avenue for the investigation of freshwater influxes into coastal reef ecosystems. Other projects within the USGS Coastal Program carry out applied research on a variety of problems related to coastal erosion and pollution. Readers are encouraged to browse Sallenger and others (1992) for a more complete description of program activities.

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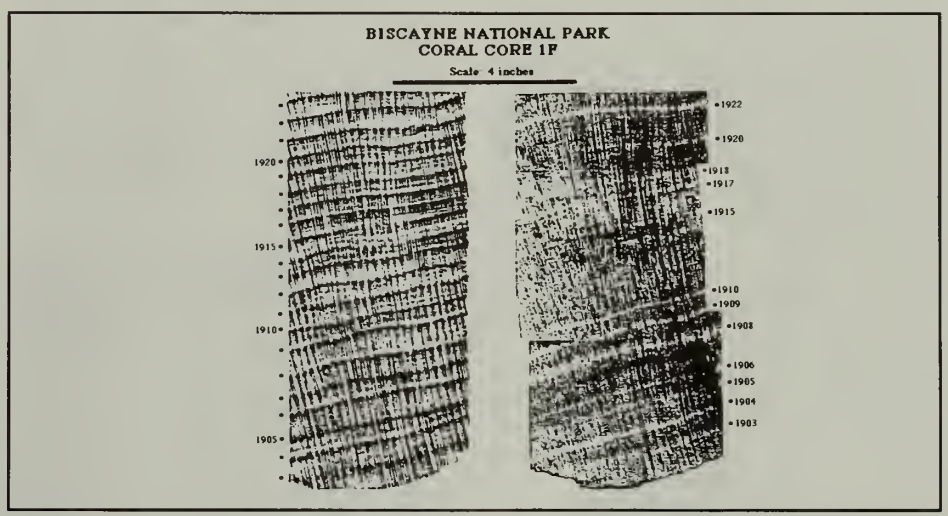

Figure 1. Images of coral skeleton samples. Image on the left is an x-radiograph revealing density variations that define annual banding in this sample of *Montastrea annularis.* Image on the right is the same sample in short-wave UV light. Light bands are fluorescing and are given dates based on density bands exhibited by the x-radiograph. Annual growth increment averages 1 cm.

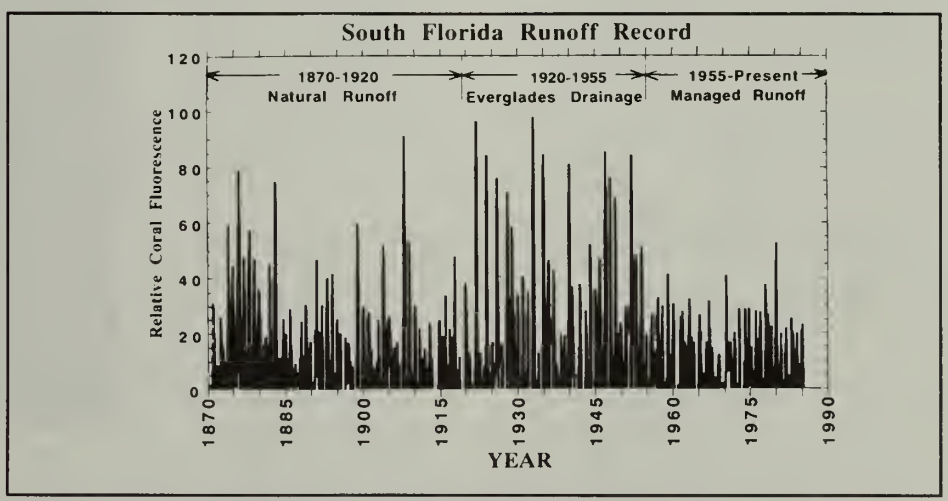

Figure 2. Plot of the relative fluoresence of annual skeletal growth intervals between 1870 and 1987. Fluorescence intensity is a proxy for fresh-water runoff from south Florida into Biscayne NP nearshore reefs.

Volcano Studies in National Parks

--USGS helps NPS to keep a watchful eye on restless volcanoes while improving our understanding of how volcanoes work--

James Riehle, Raymond Herrmann, Charles Bacon, Barbara Samora, and Christina Heliker

Of 65 U.S. volcanoes that have been active over the past 2,000 years (Wright and Pierson, 1991), about 20 are within or near a national park or monument (Fig. 1). One park, Yellowstone, was the site of extensive volcanism as recently as 70,000 years ago and continues to be restless as evidenced by slow ground deformation there. An active volcano in a park can challenge park managers: eruptions are both a grand natural spectacle and a scientific laboratory, but they can threaten park visitors and facilities as well.

Eruptions involve a variety of processes. A lava flow can bury everything in its path. A vent and associated ground deformation can develop where none had been before, damaging roads and facilities. Explosive eruptions such as Mount St. Helens (1980) typically have widespread impact: airborne ash can fall thick enough to collapse roofs miles from the volcano, pose a hazard to aviation, and can be a nuisance up to hundreds of miles away. Fast-moving pyroclastic flows incinerate or suffocate anything in their path and are mobile enough to jump ridges. Floods and landslides can occur even without an eruption; mudflows in the Philippines, for example, have resulted from rain-induced erosion of 1991 ash deposits of Mount Pinatubo. The mudflows have forced thousands of villagers to evacuate their homes and will recur for years.

Geologic information is of value to park managers for siting and design of facilities and trails, for preparing emergency plans prior to natural disasters, and for interpreting the geologic history of a park. Information about volcanoes is the focus of the USGS Volcano Hazards Program (VHP), which has grown since 1980 in response to eruptions or volcanic unrest. VHP scientists are working with NPS managers and resource specialists in several parks, providing hazard maps, advising about eruptive activity, and helping with interpretation. Equally important, studies of volcanoes in these parks serve to better our understanding of how volcanoes work and to improve monitoring techniques. Three parks serve to illustrate the benefits of these cooperative efforts.

A) Hawaii Volcanoes NP (HVNP)

The USGS Hawaii Volcano Observatory (HVO), the oldest volcano observatory in the U.S., is located at the summit of Kilauea Volcano. Kilauea and nearby Mauna Loa are partly within HVNP. Because these volcanoes are frequently active, HVO has been fertile ground for the development and testing of volcano monitoring techniques that can be used throughout the world. HVO studies have also expanded our understanding of how basalt magma forms, rises, and erupts. HVO staff offer lectures and field trips to HVNP staff and have provided a volcanic hazard map that is used by park planners (Wright and others, 1992).

The present ongoing eruption of Kilauea began in 1983 (Heliker and Wright, 1991). During eruptions, HVO staff constantly share new information with park staff. Based on HVO predictions, HVNP rangers close roads to the public and evacuate areas where and when lava is likely to break out. HVO also warns of likely sites of ground subsidence caused by underground movement of magma. Park managers and staff rely on HVO interpretations to determine safe viewing areas for visitors and to take preventive measures to control forest fires set by lava flows.

B) Crater Lake NP (CLNP)

Crater Lake is sited in a caldera, a basin formed when a volcano subsided due to rapid

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Figure 1. Index showing U.S. volcanoes active in the past 2,000 years (dots; after Wright and Pierson, 1991) and nearby national parks or monuments. NP = national park; PRE = preserve; NM = national monument.

Figure 2. View of Mount Rainier from the Tolmie Peak fire lookout in the northeast corner of Mount Rainier National Park. Note the steep slopes and extensive cover of snow and ice. Photo courtesy of Mount Rainier National Park.

Long-Term Monitoring and Research in Lake Powell

By G. R. Marzolf and Charles W. Wood

Lake Powell, the reservoir behind Glen Canyon dam, is at the heart of the Glen Canyon National Recreation Area (NRA) and is one of the nations's largest reservoirs. Recreation and tourism on Lake Powell, in Glen Canyon NRA, and in Grand Canyon NP are increasing rapidly.

Given historic conflicts over water shortage in the southwest, Lake Powell is one of the most visible reservoirs in terms of water economics and policy. The Glen Canyon dam is crucial for controlling water supply to the Lower Basin of the Colorado River and for generating hydropower. Superimposed on all of this are multiple and overlapping state and federal responsibilities for management and monitoring for compliance with water quality standards and regulations.

Lake Powell is a complex limnological system whose hydrologic regime causes considerable year to year variation in water quality and quantity. The chemically variable flows of the Colorado River into this deep, voluminous reservoir cause a complex interaction between thermal and salinity induced density structure. The high spring flows cause high spatial variability in chemical constituents and biological productivity.

Quality of water the Colorado River downstream from Glen Canyon dam is dominated by these processes in Lake Powell. The discharge volumes and flow velocities of the river discharging from Lake Powell are usually so overwhelming that any subsequent physical, chemical, and biological processes do not change either temperature or the concentrations of most constituents in the entire reach from Glen Canyon dam to Lake Mead. There may be tributary influences during infrequent and unpredictable flooding, but most of the time Lake Powell discharge dominates the water quality of the river.

Figure 1. Lake Powell is located in the canyon country of Utah-Arizona. Access to pristine wild lands is part of its recreational attraction.

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VOLCANO STUDIES ...CONT'D FROM P. 6

emptying of a subsurface magma chamber during a large explosive eruption. USGS investigations at CLNP are focused on the processes by which magma accumulated beneath the volcano and then catastrophically erupted 7700 years ago. Geologic mapping of the volcano and radiometric dating of pre-caldera lavas have improved our understanding of the volcanic history prior to the catastrophic eruption. Results will aid in evaluation of the hazards posed by the volcano and will lead to a better understanding of explosive volcanism elsewhere in the world.

Related studies at CLNP include deformation monitoring. Distances between bench marks on opposite sides of the caldera, and elevations along three road segments, are measured periodically in order to detect changes in horizontal distances and ground tilt that might be related to impending volcanic activity. Other studies, funded partly by the Geothermal Research Program of the USGS, are aimed at understanding the hydrothermal system of hot subsurface fluids that developed after the caldera formed. All post-caldera lavas were vented on the caldera floor, many of them beneath Crater Lake. Post-caldera lavas have been sampled and hydrothermal features on the lake floor have been observed by use of a manned submersible in cooperation with NPS and NPS-sponsored investigators.

C) Mount Rainier NP (MRNP)

Mount Rainier is arguably the most hazardous volcano in the conterminous U.S.: its steep slopes are weakened by fumarolic alteration, it is extensively covered by glaciers, and it is close to a major population area. The most recent eruptions occurred in the late 1800's and an eruption is likely within a few centuries (Crandell, 1973). The volcano poses a major hazard to Puget Sound and Columbia River drainages because of the potential for large mudflows of meltwater generated during an eruption. Even without eruptive activity, landslides and avalanches have occurred several times in the past few thousand years (Crandell and Mullineaux, 1967). Mount Rainier is the second most seismically active volcano in the Cascade Range (Norris, 1991) and is seismically monitored by the University of Washington and the USGS.

The volcano is sited within MRNP and is a potential threat to park visitors and facilities. Additionally, parts of Puget Sound communities outside MRNP are built on mudflows as young as 500 years (Scott and others, 1990). The NPS, USGS, and other state and federal agencies hope to better determine the nature of the hazards posed by Mount Rainier. NPS personnel and state, federal, and university geologists met recently to discuss ways to enhance monitoring, to improve our understanding of how the volcano works, and to translate these studies into a comprehensive disaster-response plan (Swanson and others, 1992).

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General Background

In the United States, about 2,500 reservoirs with capacities of 5,000 acre feet or more, provide about 480 million acre feet (MAF) of storage, thus, about 25 percent of the annual runoff can be stored. Storage capacity is dominated by large reservoirs. Almost 90 percent of the total storage occurs in 574 of the largest reservoirs. At full pool volume of 27 MAF, Lake Powell is one of the largest of these, capable of storing up to three years discharge of the river.

The Colorado River drains about 8 percent of the United States. The basin is an arid region where economic development and populations have been limited historically by the availability of water. The river flows through areas managed by the NPS, including free-flowing river reaches and reservoirs. These represent public commitment to resource preservation and recreation. The construction of the reservoirs represents similar commitment to water conservation and development for economic growth. These dual commitments have generated tension and conflict for more than a century. When management goals are incompatible, decisions are more difficult and better information is required. Thus, long-term monitoring and research on Lake Powell respond to real policy and management needs and respond to recent calls for "science for the parks" and "science in the parks" (NAS 1992).

Characteristics of reservoirs

Reservoirs differ from natural lakes in several respects. The drainage basin of a natural lake is typically about 10 times the area of the lake itself, but the drainage basin of most reservoirs is relatively larger (500 times the area of the reservoir is not uncommon). Impoundment changes many natural patterns in rivers. While the resulting reservoirs exhibit many of the same phenomena as occur in natural lakes, they tend to be more affected by water depletions and direct human uses, such as power generation.

The goal of coordinated work among scientists in the Park Service and the USGS is to better understand natural river/reservoir phenomena in order to help (1) document changing water quality conditions, (2) evaluate the implications of all possible management decisions, (3) evaluate the implications of no management actions, and (4) support and evaluate the performance of management actions.

Examples of natural and man induced aging phenomena in reservoirs.

Extinction of endemic species and the invasion of exotic species:

The recent decline of native fishes in the Colorado River is well documented. Four species of this unique fish fauna, now federally listed as endangered, are known to occur in Lake Powell and in associated inflow habitats during at least some part of their life cycle. Effort to prevent their eventual extinction must include investigation of water quality and other water-related habitat requirements. The fate of other aquatic organisms in the face of environmental change is less well known.

Scenic beaches have attracted heavy public use, predicted to increase to six million by year 2000.

Habitat alteration, such as impoundment, also creates new environments, often suitable for invading species. Furthermore, inadvertent transfer of species from native environments to new ones has increased. These may seem to be innocuous events but in some instances exotic species have caused major water resource problems.

Invasions become problems when invading species that have one or more damaging life history features are released from natural control mechanisms and respond with explosive population growth. A recent example in Lake Powell is the Asian clam, *Corbicula*, that spread through the United States in the 1960s. The introduction of predaceous fishes for sport also may have unintended negative effects.

Sediment accumulation:

Sediment deposits represent "interim sinks" for nutrients and contaminants that, prior to impoundment, were transported to the sea. Materials such as organic pesticides, toxic by-products of industry, trace metals and salts from irrigation return flow, agricultural and domestic fertilizers, etc., are of increasing concern to many water users. Between 1963 and 1986, 1.1 billion tons of sediment was deposited in Lake Powell's deltas. Lake Powell's location in the arid west and the fact that it receives return flow from irrigated agriculture suggest that sediments in Lake Powell may represent an extreme case where the study of nutrients and contaminants might be particularly useful.

Eutrophication:

Eutrophication occurs naturally as lakes accumulate nutrients that stimulate biotic productivity but human influence hastens the process and has been implicated in a wide range of problems that degrade water supplies and recreational resources.

The transport of nutrients by rivers has not caused wide-spread eutrophication problems in rivers, however, because planktonic biota are not characteristic of flowing water. Upon impoundment, however, plankton density increases rapidly and responds immediately to nutrient and contaminant inflows. Reservoir eutrophication is more an immediate response to the impoundment of flowing water than an accelerated process in a pre-existing lake. This issue has an additional twist in the case of Lake Powell because of increased recreational use as described below.

Current and emerging issues

Lake Powell is increasingly popular for recreational boating and angling. Public use of Lake Powell for recreation has increased annually reaching 3.2 million visitors in 1992, 1.5 million of these as visitor nights camping on the shores, with a projected increase to 5 to 6 million annually by the end of 1999.

A consequence to Lake Powell of this popularity is the problem of waste management in a pristine area. The list of potential contaminants includes human excreta from chemical toilets or from lakeside camping, waste water that is used for domestic washing in galley, shower, and sinks, as well as fuel spills and trash (paper products, cans, and lost equipment). There are few public access points that have the capability to treat sewage. The present facilities for handling sewage and trash are heavily taxed and inadequate to deal with the projected use.

Historically, increasing salinity associated with irrigation return flows after the construction of diversion works has been the primary water quality concern. Most available information was collected for salinity evaluation and modeling and other aspects of water quality work received less attention.

Water quality monitoring at shoreline sites on Lake Powell recently confirmed contamination by fecal bacteria in excess of established standards for body contact recreation. Addi-

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tionally, waste-water discharges could potentially affect eutrophication, particularly in embayments and canyons with limited circulation. With growing use, these problems are expected to increase.

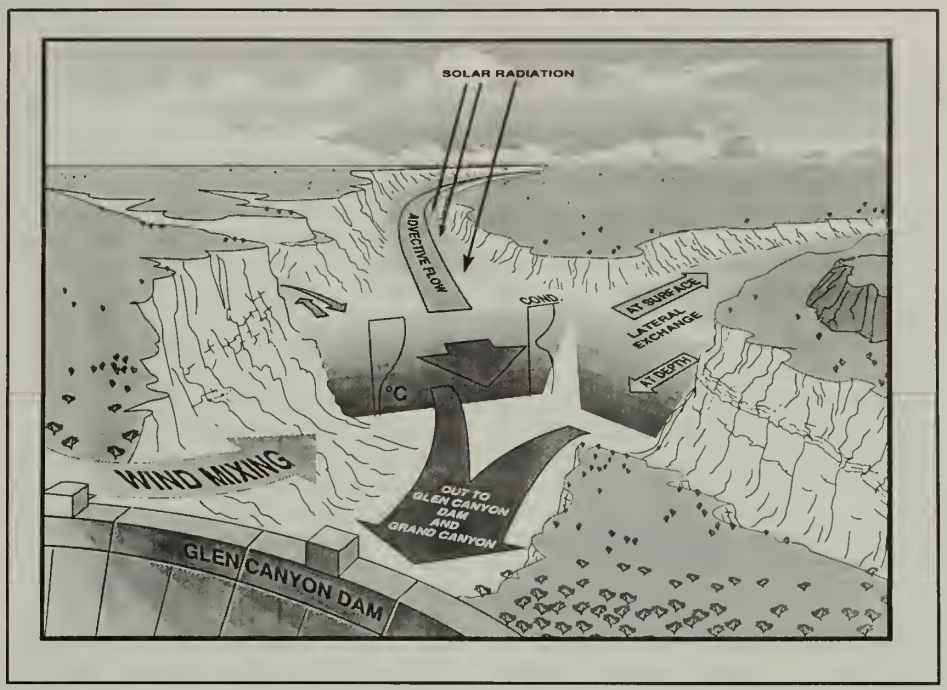
As Lake Powell was filling in the 1970s, research supported by the National Science Foundation laid the ground work for extensive work in Lake Powell, but the value of consistent and coherent long-term monitoring and research was not yet persuasive. Since Lake Powell filled in 1980 the river has had unusually high flow in 1984, 1985, and 1986 and unusually low flow since 1987. Currently, because of drought, Lake Powell is about half of its full volume. It is unfortunate that such a program was not in place to document trends and learn through this unusual decade.

Present conceptual understanding of Lake Powell relies heavily on these data, but full interpretation is difficult because attention since the '70s was focussed singularly on salinity problems to the exclusion of biological and chemical processes. Recently new concerns about the quality of inflow waters are related to irrigation, waste disposal and petroleum or mineral development in the upper basin. Because attention to preserving the integrity of this water resource is urgently required, the Park Service and the USGS have joined with the other agencies to address that issue.

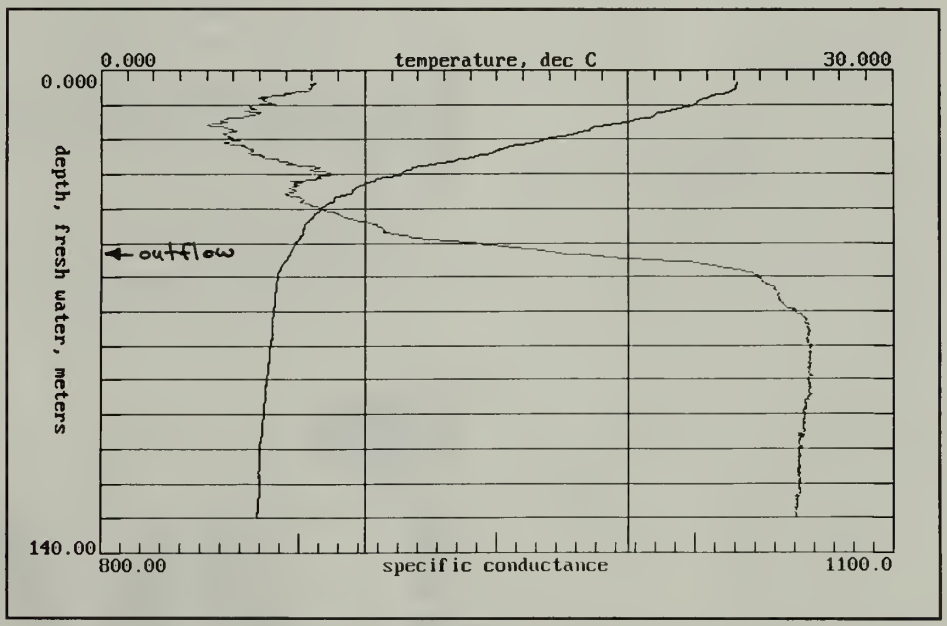
The NPS has the primary management mandate for Lake Powell and surrounding lands. Even so, other agencies have regulatory and management responsibilities and research interests. State Departments of Environmental Quality and of Game and Fish or Wildlife in Arizona and Utah, the NPS, the USGS, the Bureau of Reclamation, and the USFWS all have legal mandates for elements of operation, management, study, and understanding of Lake Powell.

The opportunity to coordinate programs, maximize the efficient use of funds already being spent to address Lake Powell's problems, and to develop new cooperative proposals for monitoring and research is extraordinary. Several interagency meetings were held at Glen Canyon NRA in 1992. They resulted in a plan for interagency monitoring and research that includes expanded water quality monitoring under existing programs by NPS and Reclamation, and a new effort to investigate contaminants in gamefishes by the USFWS. The USGS was given the charge to develop an integrated plan that serves monitoring requirements *and* also addresses the information gaps identified by participants in these work sessions.

Marzolf is with the USGS Water Resources Division; Wood is with the NPS Glen Canyon NRA.



Events and patterns in the lake are dominated by the hydrologic regime of the Colorado River; imposing a strong longitudinal effect on chemistry and biology. Superimposed on this effect is the vertical pattern resulting from insolation and density stratification associated with salinity; an important vertical structure in this deep reservoir. Third is the lateral component represented by processes in the tributary canyon embayments, hypothesized to be the most active biological areas in the lake.



A vertical profile of temperature and conductivity (an index of salinity) in Lake Powell near Glen Canyon Dam. The depth of the outflow to the Colorado River varies with lake level. These profiles were measured on July 24, 1992 when the outflow was at a depth of 52 meters.

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Energy and Mineral Resources in and near NP Lands

By Thomas S. Ahlbrandt, Kathleen K. Krohn and Gary C. Curtin

The USGS conducts energy and mineral resource assessments and related research throughout the U.S., including areas within existing and proposed National Park Service lands. The results of these activities provide objective scientific data on which stewardship decisions can be made. The USGS Office of Energy and Marine Geology (OEMG) conducts resource assessments and research in coal, oil, and natural gas, whereas mineral resource assessments and research are conducted by the Office of Mineral Resources.

The Branch of Coal Geology of OEMG conducts research that addresses coal availability and coal quality in coal fields throughout the U.S. (Fig. 1), as well as fundamental geologic controls of coal formation. Surface and subsurface data are used to determine coal quantity, which is compiled by rank, thickness, amount of overburden, and reliability of data. Additional aspects of coal quality (e.g., sulfur content) and geological, land use, and technical restrictions are commonly incorporated to estimate *coal availability*. Although formal coal resource assessments of NPS land have not been routinely performed, many products of the coal investigations program have been applied to answer specific questions concerning existing or proposed park areas. Recent examples include the pre-acquisition coal resource analysis of New River Gorge, West Virginia, and the mapping of both the Chaco Canyon area of New Mexico and the Bryce Canyon NP in Utah.

Prior to establishment of the New River Gorge as a National River, the USGS performed a coal resource assessment of the area. The resulting report, published in 1977, concluded that there are 13 coal beds of sufficient thickness and distribution to allow resource estimation, and that total remaining resources of the 440 sq km. park were estimated to be 151 million tons. The U.S. Bureau of Mines subsequently used this resource estimate as a basis for determining that slightly more than 44 million tons of the coal resources could be considered reserves (economically recoverable). These results provided essential information used to make the decision to include the New River Gorge in the National Park system.

The Chaco Culture National Historical Park has recently been mapped as part of both regional and local mapping projects. Among the products of this research effort published during 1979-1987 by the USGS, the latest map focuses specifically on interpretation of the depositional environments of Cretaceous strata exposed in the canyons, cliffs, and washes of the park. Although these studies determined that only limited coal resource potential exists within the park, they provided clear evidence that the area was a swampy coastal plain approximately 80 million years ago. These conclusions thus provide both resource information that can be used for strategic decision-making and paleogeographic information that can be used for interpretative purposes within the park.

The 1991 publication of the geologic map of Bryce Canyon NP and vicinity is an excellent example of cooperative USGS-NPS work. The report accompanying the map characterizes the entire stratigraphic sequence in the area, including two formations that have the potential of containing significant coal horizons. These are thinned extensions of important coal-bearing sequences to the east (Kaparowits Plateau) and to the south (Knab area) of the park. Although major coal deposits are not expected to underlie the park, this study provides fundamental information about park resources.

It is the responsibility of the Branch of Petroleum Geology of OEMG to assess the oil and gas resources of the Nation, both onshore and in state waters. Those results are incorporated with those of the Minerals Management Service, which conducts similar assessments for offshore federal waters, to produce a comprehensive national assessment. The latest geologic insights and updated oil and gas production data are incorporated to periodically update these estimates. In the most recent national assessment, published in 1989, the USGS for the first time separated the results for Federal, Indian, and native lands (Fig. 2). It showed that the majority of undiscovered, conventionally recoverable oil and gas resources remain on federally managed lands, either onshore or offshore.

The USGS is currently updating the national oil and gas assessment, with completion scheduled for January 1995. For the first time, unconventional resources such as coal bed methane, low permeability reservoirs (e.g., tight gas), gas hydrates, deep basin resources, fractured reservoirs, and heavy oils will be included in the resource estimates. Because many of these resources reside on federal lands liaison positions have been established between the Branch of Petroleum Geology and the NPS, Forest Service, Bureau of Land Management, and Minerals Management Service to facilitate communication regarding the ongoing assessment. The liaison for the NPS is Bruce Heise, who has been involved in several workshops and briefings on the ongoing assessment. In addition to these activities, Bruce is contributing on behalf of the NPS to a USGS Circular entitled *Oil and Gas Resources on Federal Lands*, to be published as part of a series of circulars addressing Public Issues in the Earth Sciences.

The results of the national oil and gas assessments provided the NPS with unbiased estimates of the remaining oil and gas resource potential of our nation, compiled on the scale of geologic provinces and regions. USGS estimates are commonly used as an objective and independent source of information on which land use and other management decisions regarding Federal lands are based. For example, USGS estimates of oil and gas resources in the Arches NP area are currently being used by both the NPS and the Utah Geological Survey to understand the oil and gas potential in that area as input into land management decisions.

The basic building block used in the national assessment to aggregate resource estimates to province, regional, and national scales is the *play*, defined as a group of geologically related, known or undiscovered accumulations and/or prospects that have similar characteristics of hydrocarbon source, reservoir, trap, and geologic history. A compendium of plays identified during the 1989 assessment is currently being published in four volumes as USGS Bulletin 2034, *Petroleum Exploration Plays and Resource Estimates — Onshore United States*. The

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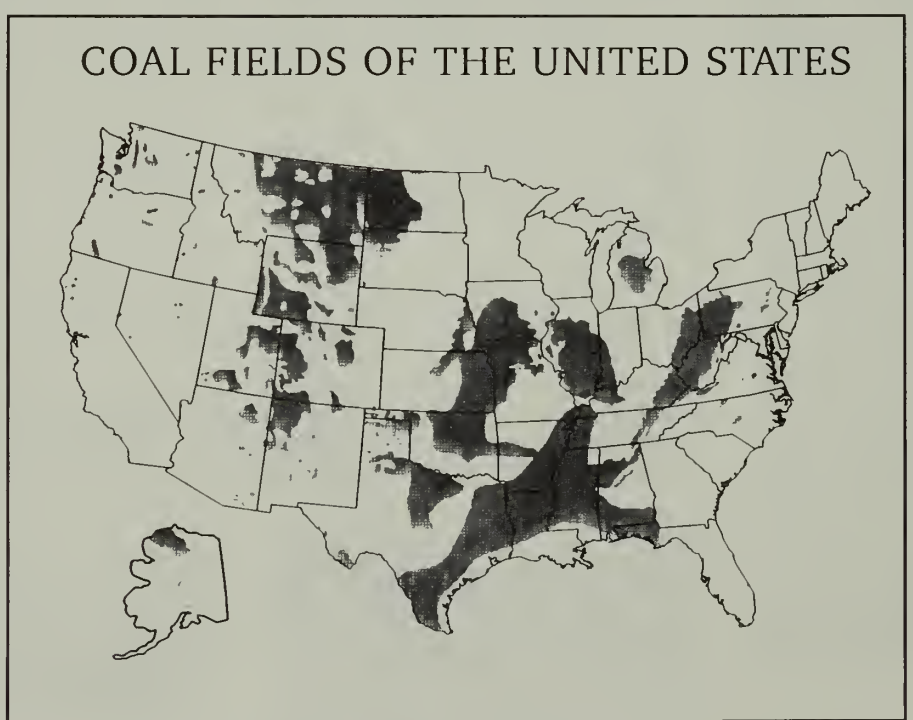

Figure 1. Map of U.S. showing distribution of coal resources.

Geologic Maps and Digital Data Sets: Their Role In Management and Preservation of NPS Lands

Beneath a surficial veneer of soil and vegetation is the highly varied assortment of rocks and sediments that constitute the outermost part of the Earth's crust. Rocks and sediments vary in composition, structure, age, mode of origin, and many other ways; these variations occur both laterally and vertically within the crust. The spatial relations of the many different kinds of rocks and sediments that can be distinguished at or near the Earth's surface are graphically portrayed through the use of geologic maps.

Geologic maps are among the most useful scientific tools available for the interpretation of Earth history. The Earth's crust has been built up, bit by bit, and through an immense amount of time, by processes as diverse as sedimentation on the sea floor, volcanic eruption, and deep-seated crystallization of molten magma; it has been deformed and modified by such processes as folding, faulting, and metamorphism; its surface has been shaped by the destructive forces of uplift and erosion. Geologic maps depict the rocks, sediments, and geologic structures (such as faults and folds) that have resulted from these processes, and which thereby record the history and evolution of the Earth's crust.

In addition to their basic value as records of Earth history, geologic maps provide information critical for a broad spectrum of practical applications. For example, the maps depict the variations in the composition, structure, and other characteristics of rocks and sediments that are directly related to the operation of the Earth's natural processes and the distribution of natural resources. Variations in the composition of rocks close to the ground surface, for example, control the composition of the overlying soil, which in turn affects the nature of the vegetative cover.

Variations in the composition and structure of rocks exposed on sloping ground control the susceptibility of such ground to erosion and downslope movement, which determines the risk to areas below from damaging debris flows and landslides. Variations in the permeability and porosity of rocks control the distribution and flow of ground water, which determines the availability of such water and its susceptibility to contamination from ground-penetrating pollutants. By forming a basis for documenting such variations, geologic maps help us avoid the negative effects of these variations or use their positive effects to our advantage, and thus achieve a more harmonious interaction with the land we live on.

Because of their unique information content, geologic maps have an important role to play in the stewardship and preservation of NPS lands, both as educational tools and as tools for balanced land and resource management. As educational tools, geologic maps can help park visitors gain insight into the geologic history and processes by which the land has been and continues to be formed. Geologic maps can also provide an indispensable framework for additional research into specific aspects of Earth history or geologic processes, the results of which can have implications that extend well beyond the boundaries of individual NPS land units.

As management tools, geologic maps contain information needed for many fundamental aspects of park management such as resource inventories, assessments of risk from geologic hazards (for example, earthquakes, landslides, volcanic eruptions, and floods), ground-water contamination studies, hazardous materials issues, construction planning, and land acquisition. In areas subject to rapid or even catastrophic geological change from the occurrence of natural hazards, accurate geologic maps also can serve as sources of baseline information for monitoring such changes through time and for predicting the effects of future changes.

Like many other types of mapping, geologic mapping is currently undergoing a major shift from the production of conventional maps on paper to the development of geographically-referenced, digital databases through the use of geographic information system (GIS) technology. More than just a computer-generated picture, a digital geologic map compiled for use in a GIS is a fully attributed data set that can be

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NP Energy and Mineral Resources Cont'd from p.10

geologic information and resource estimates presented at the play level should be useful to the NPS in updating anticipated activity levels and potential resource information on a level of detail that has not previously been available from the USGS.

The USGS Office of Mineral Resources has made many mineral-resource assessments within and adjacent to National Park lands during the past 18 years. These studies also have provided modern information on the geology, geochemistry, and geophysics of these areas.

An example of such activities that provides information for Park Service planning and other activities is the recently published mineral- and energy-resource assessment of the Mount Katmai, Naknek, and western Afognak quadrangles, Alaska, which includes Katmai NP. This assessment provides the most up-to-date information on the geology, regional geochemistry, and descriptions of known mineral occurrences together with estimates of undiscovered metallic mineral resources. The geothermal and petroleum resources of the region also are summarized in reports describing the results of the studies.

The USGS also provides mineral-resource and related geological information as planning aids for proposed national parks and monuments such as the proposed legislation H.R. 5594, *Sequoia National Monument Act*. Based on existing data, the USGS has compiled maps showing the geology and mineral occurrences of tracts that would make up the proposed Sequoia National Monument, California. The known mineral occurrences also are described and a preliminary assessment of the mineral resources of the area has been made to aid planning and definition of the boundaries of the proposed National Monument.

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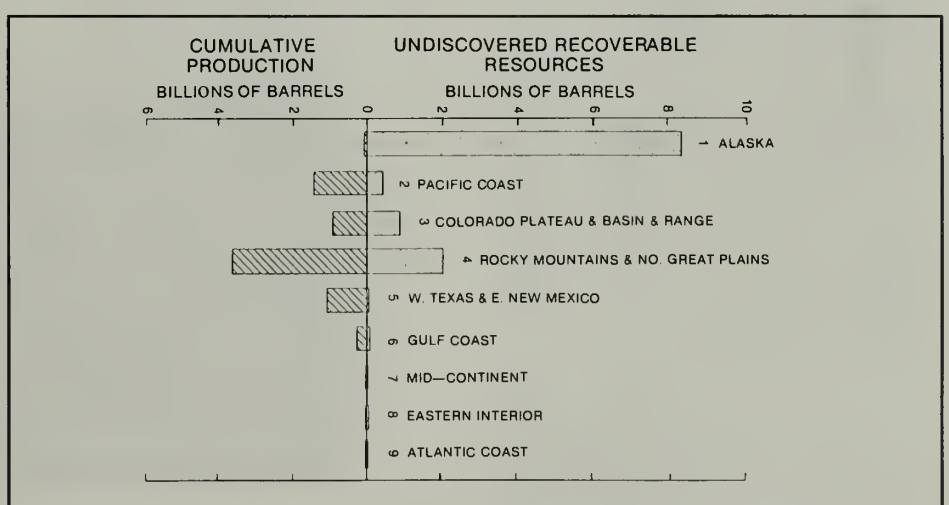

Figure 2. Bar graph showing cumulative production and estimated undiscovered recoverable oil resources on onshore Federal lands, compiled by 9 regions.

Measuring Colorado Water Quality in the Grand Canyon NP

By H.E. Taylor, R.C. Averett and L. Mazzu

The Glen Canyon Environmental Studies (GCES), a program under the Bureau of Reclamation, was created in 1983. Agencies and organizations participating in the GCES program include the USFWS, the Arizona Game and Fish Department, Arizona State University and environmental consultants to these participants. More recently, the USGS has played an important role in this effort.

These studies, under the auspices of GCES are designed to provide information on the effects of the Glen Canyon Dam and its operations on the downstream resources of the remaining Glen Canyon and Grand Canyon of the Colorado River. The information gained from such studies will be used in the environmental impact statement (EIS) analysis currently underway and in other management decisions regarding future development of water quality monitoring programs. Decisions will be made on which flows are necessary to maintain the natural processes of this riverine system. These studies have been done by the GCES with the cooperation of the Bureau of Reclamation and the NPS.

Because the interactions of sediment, river flow, water chemistry and biology, are four of the most important factors influencing the health and recreational value of the ecosystem of the Colorado River, the USGS has and continues to contribute a great deal of hydrologic research effort to GCES.

The first synoptic study under GCES focused on water chemistry and biology on different reaches and tributaries of the Colorado River and under different flow regimes downstream from Glen Canyon dam. These studies provide detailed information on water quality spatially and by flow level. Such information should assist the National Park Service not only in determining locations for long-term monitoring throughout the river corridor but also in refining management objectives that may drive decisions regarding the release of water from Glen Canyon Dam.

Synoptic sampling is used to assess, in a comprehensive manner, the characteristics or conditions of a system, such as the Colorado River, at a fixed point in time. Sampling is coordinated and carried out simultaneously at several carefully predetermined locations. These sites are selected to provide the maximum amount of information regarding important inputs or disturbances to the system.

The purpose of this type of experiment is to permit the development of a general understanding of the system and to provide a large data base of information for use in defining the spatial characteristics in as much detail as possible. In addition, the data base is useful for establishing protocols and direction for much more detailed and specific future investigations and research studies.

In the case of large river systems, repetitious sampling, closely spaced in time, can provide additional information regarding short-term variations in chemical and biological water quality in relation to a variety of physical variations including hydrologic, meteorologic, and diel conditions. Executing water-quality synoptic experiments during different seasons of the year can also provide information concerning long-term temporal variations. Collectively, this information can provide a rapid and compre-

Table 1. Chemical determinations made on synoptic samples

Nutrients	**Trace Elements Cont'd**
Nitrate	Boron
Phosphate	Cadmium
Ammonium ion	Chromium
Dissolved nitrogen	Cobalt
Dissolved phosphorus	Copper
Dissolved organic carbon	Iron
Major ions	Lithium
Calcium	Lead
Magnesium	Manganese
Sodium	Mercury
Potassium	Molybdenum
Silica	Nickel
Chloride	Selenium
Sulfate	Strontium
Trace Elements	Thallium
Aluminum	Uranium
Arsenic	Vanadium
Barium	Zinc
Beryllium	

Continued on page 13

Geologic Maps and Digital Data Sets, Cont'd from p. 11

analyzed, searched, or combined with other GIS data to produce derivative maps and data sets designed to address specific research or management problems. Geologic data can be combined with topographic data, for example, to produce derivative maps of slope stability and landslide potential; with hydrologic data to produce derivative maps of ground-water contamination potential; and with soil and vegetation data to produce derivative maps of land cover useful for forest, range, or wildlife management.

Thus, through GIS technology, geologic maps are being transformed from traditional graphic displays into digital data layers that can be used interactively with other types of data in a wider variety of applications than has been possible in the past. This analytical capability, plus the ease with which digital data sets can be updated and revised, clearly point to a future in which the production of geologic maps in digital format will be the norm rather than the exception.

The development of a nationwide, digital database of geographically- referenced geologic information is the principal objective of the U.S. Geological Survey's National Cooperative Geologic Mapping Program, which was established by Congressional legislation enacted on May 18, 1992. The database will be developed through the design and execution of geologic mapping projects and supporting scientific investigations that meet prioritized Federal and State needs for geologic information. The program is intended to foster communication and cooperation between the producers and users of geologic-map information so that the areas in most urgent need of this information can be identified and the production of the information in those areas accelerated.

An essential factor for the timely development of a nationwide, digital geologic-map database is increased cooperation between the USGS and other Federal agencies that either use or produce geologic information. The NPS has an obvious interest in high-quality, digital geologic information for multiple-purpose GIS applications, particularly in light of the ongoing establishment of the new NPS's Inventory and Monitoring Program and the NPS's long-standing commitment to public education in matters relating to the natural environment. The growing USGS-NPS partnership for geologic data-base development in NPS lands should benefit both agencies by accelerating progress toward mutual objectives.

The partnership builds on a long history of project-level cooperation between the USGS and the NPS, one that has resulted in the publication of geologic maps and related interpretive studies of many individual NPS land units over the years. In the past three years alone, for example, the USGS has published geologic maps of Yosemite, Rocky Mountain, Grand Teton, and Bryce Canyon NPs. The production of geologic maps, digital geologic data sets, or both is currently ongoing in several other NPS units, including Kings Canyon, Sequoia, and Great Basin NPs and Chiricahua National Monument. Despite such individual successes, an even broader framework for cooperation is needed in the future to facilitate logistics and funding, to encourage the application of uniform standards of geologic mapping and data-base development, and to ensure that the work is conducted in a prioritized manner that satisfies the needs and mandates of both agencies.

For further information on available geologic-map data and ongoing USGS geologic mapping projects, for discussing potential cooperative studies, and for information about the National Cooperative Geologic Mapping Program, contact:

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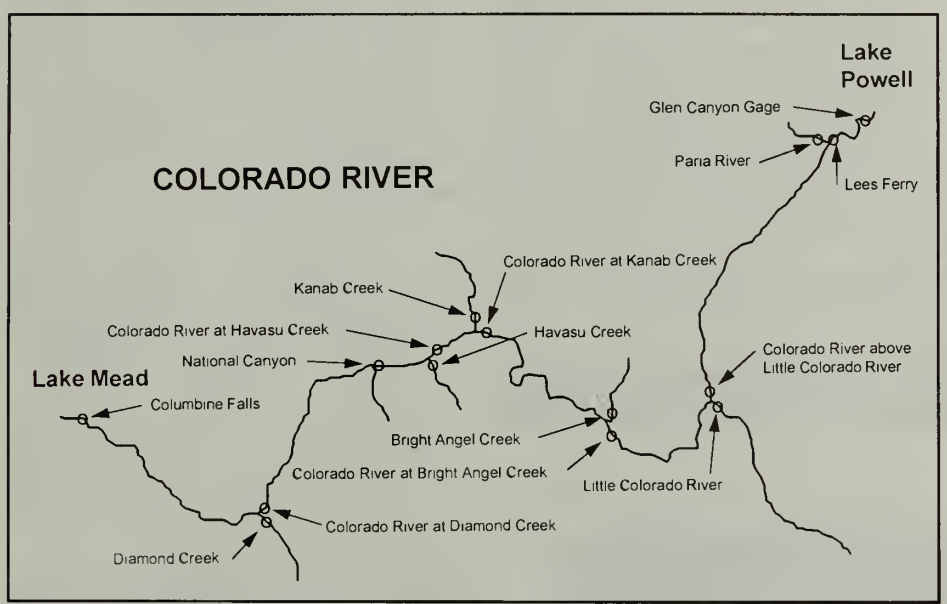
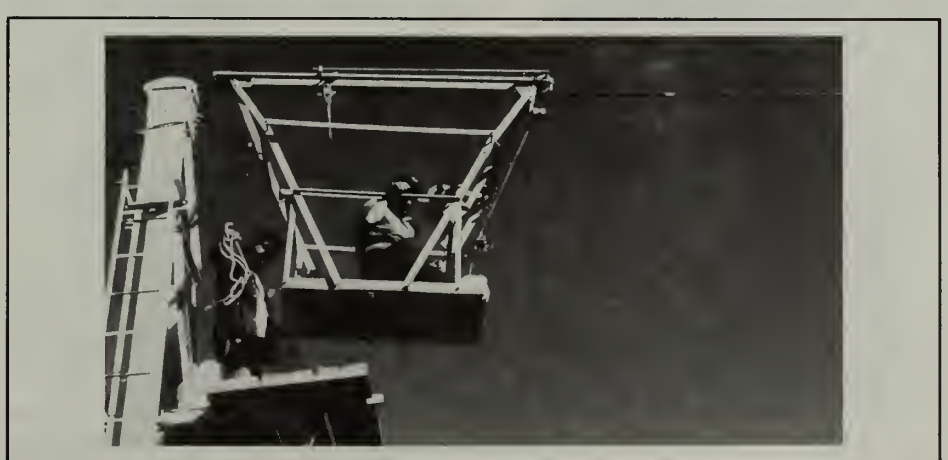
hensive analysis of the status and variability of the water quality in a large and complex river system. Differentiation of unstable properties, the significance of the magnitude and diversity of important components, and the sensitivity of their response to physical variables provide a systematic way to evaluate present and future water-quality conditions.

Such a water-quality synoptic experiment was conducted on the Colorado River, Nov. 5 and 6, 1990. Ten mainstream river stations and 6 tributary stations (at confluence) were selected for water-quality measurements and sample collection for chemical and biological analysis. A total of 470 river kilometers (the tailwater of Glen Canyon Dam to Columbine Falls) was included in the synoptic experiment. Included also was the forebay of Lake Powell formed by Glen Canyon Dam where the water that would ultimately be released into the river was sampled.

Samples collected by wading used the DH-81 Sampler



Colorado River showing sampling station localities and river miles from Lees Ferry for the 11/5/90 USGS water-quality synoptic studies. o-indicates sampling localities



Cableway, used in synoptic experiments for water sample collections on the Colorado mainstream.

Sixty-eight people (all but four from the USGS) participated in the synoptic experiment. At each mainstream sampling station, or combination mainstream-tributary station, a team leader was designated. The team leader was assigned the responsibility for directing the sampling, processing samples, and recording field data. Training of team leaders and team members on field measurements and sample collection was performed on Oct. 29, 1990, at Lees Ferry, AZ. Three training sessions, including 3 to 4 hours of classroom instruction and riverside equipment demonstration and use, were presented by scientists from the USGS National Research Program.

After training and equipment testing, personnel were transported to their assigned sampling locations. Personnel were at their stations by late Saturday, Nov. 3, 1990. Sunday, Nov. 4, 1990, was used to establish local sampling schemes, and field-measurement sites, and to practice measurements and sample collection.

Of the 10 mainstream Colorado River sampling stations, 6 have cableways that cross the river for discharge measurement and sample collection. The cableways were used in the synoptic experiments for water-sample collection. At stations where a cableway was not available, sampling and measurements were performed using a winch and boom mounted on a boat. In small tributaries, samples were collected by depth-integrated discharge-weighted procedures. The samples from the cableways and by boat were collected by the D-77 sampler, modified to permit use of the collapsible-bag technique as described by Meade and Stevens (1990). Samples collected by wading used the DH-81 sampler. In both cases, sampling equipment was designed and configured to maintain the integrity of samples for low-level trace-element analysis.

Field measurements and sample collection began at 6:00 am on Monday, Nov. 5, 1990, and continued every 6 hours thereafter, until and including midnight, Nov. 6, 1990. This scheme provided 8 measuring and sampling times over a 48-hour period, accommodating diel variations and fluctuating river stage caused by variable water release from Glen Canyon Dam. All subsequent water samples for chemical and biological analysis were field-filtered and preserved, if necessary, at the time of collection. The samples were shipped chilled to the USGS National Research Program laboratory at Arvada, CO, for laboratory analysis (Taylor and others, 1990).

Field measurements at each station included river and tributary discharge, temperature, alkalinity, specific conductance, pH, dissolved oxygen concentration, and Secchi-disk depth. About

Continued on page 14

NPS/USGS Cooperative Biochemistry Studies

By Larry Jackson

In 1983 the USGS and the NPS signed an interagency agreement which facilitates joint investigations of the influences of human-induced (anthropogenic) atmospheric emissions of trace metals and sulfur on vegetation and soils in and near selected NP lands. Studies are in progress or have been completed at Theodore Roosevelt, Big Thicket, Redwood, Great Smoky Mountains, Everglades/Biscayne, Wrangell-St. Elias, and Denali NPs and the Santa Monica Mountains NRA. Studies have focused on developing baselines for various chemical elements to be used in assessing environmental degradation, in examining spatial trends of plant and soil chemistry with respect to contamination sources, and in investigating biogeochemical processes that influence our ability to discriminate between elements of natural and anthropogenic origin.

While study designs and specific objectives differ from one park region to another, establishing baseline geochemical and biogeochemical levels has been an important starting point for each project. Elemental content of soils and vascular plants, lichens, and mosses have been used to establish modern-day baseline ranges and to examine the spatial and temporal variability of specific element concentrations. Regardless of the source of contamination, it is difficult to assess the extent of contamination without an understanding of a background value. It is virtually impossible, however, to obtain a true "background" value. The historical data simply do not exist. Attempts have been made at estimating background values by analyzing certain plant specimens, by making comparisons with the most pristine locations from around the world, and by a variety of other techniques.

An alternative to estimating a true background element concentration (before any human impact) is to determine a contemporary baseline range against which future changes may be measured. For the areas in which we have had research projects, there are almost no chemical data that indicate the magnitude of element concentrations or the spatial or temporal variability against which comparisons may be made. Although the elemental content of a particular plant species may have been measured at a different location, differences between regions and even between micro-habitats may significantly affect the elemental content of plants or soils. Hence, we have worked to establish a reference point for a particular region at a specific time. In our work, this has been defined usually as the 95 percent expected concentration range for an element in a specific plant species, plant part, or soil horizon at a specific time.

Seasonal cycling of elements or other episodic changes in element content may produce a significantly different baseline range; thus, it is important to understand the processes controlling element mobility in an environment in order to use ranges that are measured for one particular point in time. In addition to establishing elemental baseline ranges, these studies have helped to understand the impact from point pollution sources (such as from a chemical spill) and non-point pollution sources (such as from the widespread application of insecticides) and to define future research needs for biomonitoring programs.

The establishment of element baseline ranges is typified by our work in Theodore Roosevelt, Redwood, and Denali NPs where lichens and mosses are being used as air quality monitors. Scales of spatial variability in element concentrations in *Parmelia sulcata* and *Parmelia chlorochroa* in Theodore Roosevelt NP, *Hypogymnia enteromorpha* and *Usnea* spp. in Redwood NP, and *Peltigera aphthosa* and *Hylocomium splendens* in Denali NP were examined using analysis of variance sampling designs. Baseline element concentration ranges were determined for those elements which did not exhibit large geographical concentration trends and for which analytical measurement error was not a large proportion of the total element variability.

Similar studies have been done in Everglades NP and Santa Monica Mountains NRA to establish baseline element concentration ranges for vascular plants. In the Santa Monica Mountains *Ceanothus megacarpus* and *Rhus laurina* were sampled and analyzed. Large seasonal differences in some nutrient and nonessential element concentrations were observed in the two chaparral species. In addition, some spatial trends were noted which may be due to their proximity to anthropogenic emissions or differences in the geochemistry of the soils throughout the region. These seasonal and spatial trends make the establishment of baseline ranges difficult. These trends also point to the importance of understanding the processes controlling biogeochemical cycling in an individual environment in order to have an effective biomonitoring program.

Jackson is with the USGS in Denver, CO

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Measuring Colorado Water Quality: Cont'd from P. 13

780 field measurement were made during the synoptic experiment. Water samples were collected for analysis of chemical and biological characteristics and suspended-sediment concentration. Chemical determinations are listed in Table 1. Biological determinations included drift biomass collected with 100 mm orifice-diameter nets at all sites and 0.5 M orifice-diameter nets at selected sites; benthic invertebrates at the lowest flow in the main stem Colorado River and at sampling-time flow in the tributaries; phytoplankton and zooplankton abundance; and, at several stations, chlorophyll a concentration (Averett and Iwatsubo, in press). About 2,300 water samples were collected for chemical and biological measurements. In addition to the specific determinations, team leaders and team members were careful to make detailed notes on river conditions, including floating material in the river, and to take pictures of the river and sampling sites at the time of the synoptic experiment.

Summary

Synoptic sampling provides a way of rapidly evaluating water quality in large river systems. These data are especially useful in guiding future research directions. By designing time variation in the synoptic sampling, additional information can be obtained regarding temporal changes in chemical and biological properties.

Taylor and Averett are with the USGS in Boulder, CO; Mazza is with the NPS at Grand Canyon, AZ

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Fossils, U.S. Geological Survey and the Public Lands

By John Pojeta, Jr.

Knowledge of fossils is critical to understanding Earth history and past life. Fossils allow geologists to establish time lines by which scientists can correlate past events, and fossils are the direct evidence of the evolution of species over the past 3.45 billion years.

Within the National Park Service (NPS), the U.S. Geological Survey (USGS) has two formal ongoing cooperative studies at Petrified Forest National Park (PFNP) and Dinosaur National Monument (DNM). Fossilized spores and pollen are being recovered from the Mesozoic Chinle and Morrison Formations. These plant microfossils are analyzed to interpret the geological history and paleoenvironments of these formations, which are geographically widespread in the Western Interior. These formations crop out in the northern and southern Rocky Mountains and in the Colorado Plateau region. The rocks contain economic deposits of uranium and vanadium, and are renowned worldwide for the diverse and well-preserved Mesozoic fossils they contain.

The research on the Chinle Formation at PFNP is a topical study in support of the National Cooperative Geologic Mapping Program. The USGS project is led by Ronald J. Litwin, who works cooperatively with Park Superintendent Gary Cummins, Chief Ranger Kerry Isensee, and Park Paleontologist Vincent Santucci. The exposures of the Chinle Formation at the Park have provided the opportunity to establish the fossil pollen transition across the boundaries of two of the stages in the Late Triassic near the beginning of dinosaur evolution. Previously, similar studies of Late Triassic pollen and spores were done at Manassas Battlefield National Park, Virginia.

The DNM studies are coordinated by Christine Peterson (USGS, Denver) and Dan Chure (Park Paleontologist, DNM.) Pete Peterson (USGS, Denver) is the senior scientist in this multidisciplinary examination of the biostratigraphy and lithostratigraphy of the Upper Jurassic Morrison Formation. Ron Litwin is examining the fossil pollen and spore succession from all major dinosaur quarry sites in the Morrison Formation in the west. Until this work commenced, the documented record of pollen from the Morrison was sparse. However, more than a dozen new pollen sites have been discovered to date, and over 150 samples are currently under study.

The USGS is the Federal agency charged with collecting, studying and publishing reports about fossils. Throughout most of the 113-year history of the USGS, paleontologists have been placed in a separate administrative unit. For much of the 20th Century, this unit has been called the Paleontology and Stratigraphy Branch (P&S). At the present time, P&S has 51 paleontologists.

Paleontological expertise in P&S covers most aspects of research on fossils. Studies of invertebrate fossils are performed on clams, snails, ammonites, and various smaller groups of mollusks throughout the known time ranges of these shells; Paleozoic brachiopods; graptolites; trilobites; and Paleozoic corals. Vertebrate studies include Cenozoic mammals and trace fossils, dinosaurs, and Triassic trace fossils. Paleobotanical research is conducted on both plant and pollen fossils from Paleozoic, Mesozoic, and Cenozoic rocks. Micropaleontological studies include pollen, marine and fresh water diatoms, ostracodes, nannofossils, foraminifera, dinoflagellates, conodonts, and radiolarians, throughout most of the known time ranges of each of these groups.

Within the USGS, paleontological studies are important to the success of a number of programs including National Cooperative Geologic Mapping, Global Change and Climate History, National Mineral Resource Assessment, Evolution of Sedimentary Basins, Coal Investigations, Oil and Gas Investigations, Offshore Geologic Framework, and Earthquake Hazards Reduction.

In addition to cooperative projects with NPS, the P&S Branch also carries on studies in support of other government agencies including Department of Energy at the Savannah River Plant and the USAID Coal studies in Pakistan. In cooperation with the Water Resources Division of the USGS, the Branch is also conducting stratigraphic studies in Abu Dhabi of the United Arab Emirates. In the recent past, P&S has conducted studies for the Department of Defence at Enewetak Atoll and for the Department of Energy at Yucca Mountain.

The P&S Branch also regularly identifies fossils for a wide variety of organizations and individuals, including other USGS research projects, universities, State geological surveys, individual citizens, and other Federal agencies. In this last category, P&S has most recently worked with the Bureau of Land Management (BLM) the Forest Service (FS).

In May 1992, the USGS, BLM, NPS, and FS, signed a Memorandum of Understanding (MOU) for "Management of Fossils on Public Lands." This MOU created an interagency working group known as "The Federal Interagency Paleontological Working Group" (FIPWIG). This working group consists of: Chief, Branch of Paleontology and Stratigraphy (USGS); Chief, Division of Recreation, Cultural, and Wilderness Resources (BLM); Chief, Wildlife and Vegetation Division (NPS); and Geology Program Specialist, Minerals and Geology Management Staff (FS), or their delegates. The USGS delegate to FIPWIG is the permanent working group chair. FIPWIG meets early each fiscal year to identify and prioritize anticipated needs of the land managing agencies. Additional meetings can be convened as required.

Also in May 1992, Public Law 102-285 the "National Geological Mapping Act of 1992" was enacted. Among other things, this act established the "National Cooperative Mapping Program" (NCMP). One of the program objectives of NCMP is "Development of a...national paleontologic data base.... Representative categories of interdisciplinary support shall include...paleontologic investigations that provide information...to a national paleontologic data base..." The National Paleontological Data Base (NPDB) will be maintained by the USGS as authorized by the legislation.

Since its founding, the USGS has been assembling data on the Nation's fossils, and these data form the core of the NPDB. The data base already has information on about 250,000 fossil localities from which information can be supplied to land-managing agencies. New research is continually expanding the data base, and a dedicated effort is being made to make the NPDB as complete as possible.

Pojeta is with the USGS in Reston, VA

Figure 1: Senator Gore and Mrs. Gore with USGS scientists examining dinosaur footprints in Upper Triassic lake deposits near Culpeper, Virginia.

Modeling the Effects of Climate Change on the Thermal Structure of Yellowstone Lake

By Steve Hostetler with Introduction by John Varley

In 1868, explorer Legh Freeman called Yellowstone Lake "... the largest and strangest mountain lake in the world." Indeed, current scientific research concentrates on many of the lake's more complex and subtle enigmas. The lake is cold yet it straddles a geological hot stove. The outlet of the lake is continuously being raised and lowered by geothermal activities. The great depths of the lake are still being surveyed by robot camera; and, over the past year, a diatom unique to the lake was described, and the first underwater geyser was found in the lake. Today Yellowstone Lake supports an abundant population of Yellowstone cutthroat trout that are a primary food source for wildlife (pelicans, osprey, eagles, bears) and are the basis of an important sport fishery. The many facets of Yellowstone Lake make it a priceless natural treasure.

Modeling Study

The annual cycle of water temperature plays a key role in the water balance and productivity of Yellowstone Lake. The surface water temperature and the water balance of the lake are linked through evaporation. Productivity is influenced by characteristics of the temperature structure such as duration and thickness of ice cover, onset of stratification in spring, the strength and duration of stratification through summer, and turnover in autumn. An investigation of the temperature structure of Yellowstone Lake has been underway for the past 15 months together with investigations of the water budget and productivity of the lake. The findings of these studies will be used to reconstruct the climate of the basin over the historical record and for the Holocene. These investigations are cooperative studies that involve personnel from the National Park Service, USFWS, USGS, the University of Minnesota, the University of Oregon, Oregon State University, and the Philadelphia Academy of Sciences.

The goal of the lake modeling study is to apply a previously developed thermal model (Hostetler and Benson, 1990; Hostetler, 1991). The model is one-dimensional and is used to simulate thermal structure, evaporation, and ice cover in response to meteorological conditions (solar radiation, atmospheric radiation, air temperature, humidity, and wind speed). Over the past 15 months the meteorological data has been collected hourly at a site on the northern shore of the lake; data collection will continue for another 1 or 2 years. Profiles of water temperature and data on the duration of ice cover, ice thickness, and depth of snow on the ice also are being collected to provide information to compare with results of model simulations.

Results from a 449-day (June 28, 1991 to Sept. 9, 1992) simulation indicate that the model is able to predict the thermal characteristics of the lake, including lake surface temperature (Fig. 1) and ice cover for the winter of 1991-92 (Fig. 2). Preliminary comparisons of simulated and observed data (USFWS, unpublished data, E. Theriot, Philadelphia Academy of Natural Science, personal communication) indicate that the model closely simulates the actual surface temperature of the lake for the period. The simulated date of fall turnover in 1991 was Oct. 12, a date within the estimated period of actual turnover. The onset of total ice cover over the lake was simulated to be December 18, a date within a few days of the observed onset (Dec. 13; J. Lounsberry, A. Siebecker, NPS, personal communication). The winter of 1991-92 was the warmest on record in Yellowstone Park. As a result, the maximum ice thickness of 0.85 m was less than normal (> 1 m) and simulated values agree well with a mid-winter measurement (C. Whitlock, University of Oregon, personal communication). Another result of the warm, relatively dry winter was that break-up of the ice occurred earlier than normal. The date of break-up simulated by the model (May 4) is within a few days of the observed break-up (May 7). Following break-up, cool, windy conditions prevailed and the lake was observed to mix for a period of more than 2 weeks. This period of mixing is captured by the model and is indicated by the slow rise of water temperature that was simulated until about the first of June, 1992.

Because the lake model simulates evaporation in response to climatic conditions, it also will be used to evaluate the present and past water balances of Yellowstone Lake. Knowledge of the water balance is important to making estimates of lake level. A field project is currently in progress at the lake to evaluate the water balance.

The thermal model will be used to investigate the effects of climate on the productivity of Yellowstone Lake in several ways. For example, the onset and level of spring productivity under ice depends on the intensity of light (solar radiation) penetrating the ice, and the associated convective mixing that is initiated by heat from the penetrating radiation. The model can be used in sensitivity tests to link climatic-determined conditions of the ice (e.g., presence or absence of late spring snow) with productivity. For Holocene climate reconstructions of the lake, the model and data set will be used to reproduce thermal characteristics (e.g., spring mixing, onset and strength of stratification) that are favorable to diatom assemblages identified in sediment cores obtained from the lake.

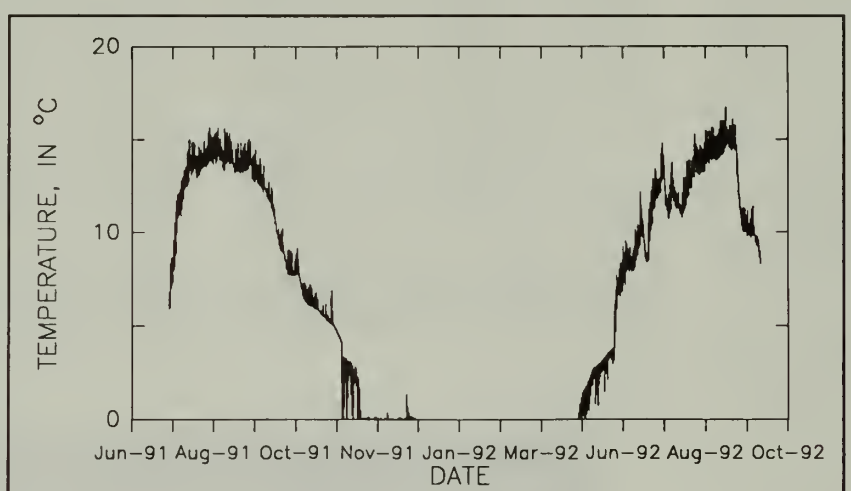

Figure 1. Simulated hourly values of the surface temperature of Yellowstone Lake.

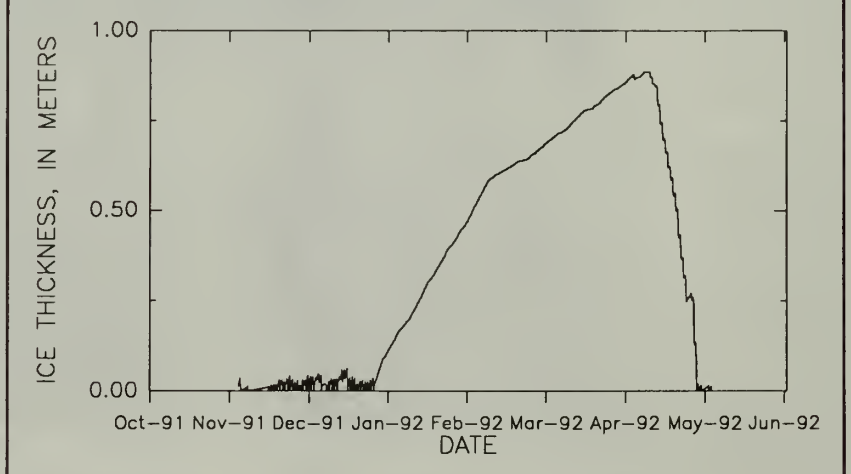

Figure 2. Simulated hourly values of the thickness of ice on Yellowstone Lake.

Hostetler is a research hydrologist with the USGS in Boulder, Colorado; Varley is head of research at Yellowstone NP.

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information crossfile

Yellowstone Science is the title of a new quarterly publication devoted to the natural and cultural sciences and edited at Yellowstone NV by Paul Schullery. Volume I, Number 1, Fall 1992 is a 24 page issue, featuring articles on Global Climate Change in Greater Yellowstone (by William Romme and Monica Turner), Bugged Bears and Collared Cougars (by Mark Johnson), Confidence in the Past (an interview with paleoecologist Elizabeth Barnosky), News and Notes, and Dennis Knight's review of Don Despain's book, **Yellowstone Vegetation: Consequences of Environment and History in a Natural Setting** (Roberts Rinehart Publishers, Boulder, CO, 1990. 239 pages; $14.95 paper).

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"Social Science and Protected Area Management: The Principles of Partnership," a plenary session speech delivered at The World Parks Congress in Caracas in February 1992 by Gary Machlis, will be carried in a future issue of the George Wright Society FORUM. Machlis proposes that the management of protected areas is necessarily the management of people. "In the past decade," he told the Congress, "there has been a growing realization that biological and social systems are inextricably intertwined. Hence, the social sciences have emerged as a partner to conservation biology and protected areas management. Issues include visitor management, sustainable development, economic impact and equity, the social impacts of tourism and more; in short, many of the issues central to contemporary conservation."

Machlis poses these questions: "What exactly have the social sciences (anthropology, economics, geography, psychology, political science, and sociology) contributed that is 'usable knowledge' for protected area managers? What contributions can be expected in the future? How should the social sciences be organized to deliver insight and expertise to the protected area movement?" For Machlis's answers, read FORUM.

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From Gary Sullivan in the Midwest Regional Office comes word of several information sources he recommends:

The Young Entomologists' Society International Entomology Resource Guide (Fourth Edition), updated, expanded, and revised, with emphasis on insect study through educational resources and materials; $10.00 postpaid; mail order and payment to Young Entomologists' Society, Dept. RGN, 1915 Peggy Place, Lansing, MI 48910-2553;

Index of Mosses, 1963-1989 contains 8,500 names and includes all new taxa from the rank of genus and below. Monographs in Systematic Botany, Vol. 42, 656pp, hard bound, June 1992; $25.00, $2.00 shipping. Prepay to Dept. 11, Missouri Botanical Garden, P.O. Box 299, St. Louis, MI 63166-0299;

The Manual of Natural History Curatorship, edited by Geoff Stansfield, John Mathias, and Gordon Reid, will be available from HMSO Books in early 1993, providing a comprehensive introduction to the philosophy, administration, and management of natural science museums and natural science collections. Contact HMSO Publications Centre, P.O. Box 276, London SW85DT;

The Aquatic Plant Information Retrieval System (APIRS) collects information about aquatic plants. Free of charge, users may request and receive computer generated bibliographies. APIRS depends on direct contributions from users to maintain this service. Please send reprints, book announcements, newsletters, etc., to Center for Aquatic Plants, Institute of Food and Ag Sciences, U/FL, 7922 NW 71st St., Gainesville, FL 32606.

Sullivan also sent news of a new facility, the Museum of Biological Diversity, dedicated at Ohio State University in Columbus on Dec. 3, 1992. It encompasses more than 55,000 square feet of collections, labs, and graduate instructional space and is to house all the university's biological collections. For more information contact Tod F. Stuessy, Museum Director, College of Biological Sciences, OH/State/U, 484 W. 12th Ave., Columbus, OH 43210-1292;

And news of the National Museum of Natural History's 1993 Research Training Program for students interested in systematic biology and natural history research. This 10-week intensive program, May 22-Aug. 1, includes a research project, lectures, discussions, tours, field trips, lab and collections work, and the opportunity to learn from Smithsonian scholars. Contact: Mary Sangrey, Program Coordinator, NHB 166, Smithsonian Institution, Washington, DC 20560, (202)357-4548.

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Restoration Ecology, the new journal of the Society for Ecological Restoration, will present its first issue at the beginning of 1993. It will emphasize the technical and scientific elements of restoration and will include refereed research papers, reviews, and reader opinions. The journal's editor-in-chief is William Niering of Connecticut College. Edie Allen of San Diego State University is serving as associate editor.

Climate Change Conference

David L. Peterson, Research Biologist (U/WA CPSU), attended the International Conference on Mountain Environments in Changing Climates, in Davos, Switzerland in October 1992. He presented a paper titled "Recent changes in the growth and distribution of subalpine forests in western North America." The highly interdisciplinary meeting was attended by scientists from climatology, geosciences, biology, and sociology.

Peterson also visited with scientists at the Swiss Federal Institute for Forest, Snow, and Landscape Research in Birmensdorf. Dr. John Innes, director of the Swiss forest survey, hosted this visit, as well as a pre-conference excursion in the Swiss NP.

Director Accepts Academy Report Recommendations

The National Research Council (NRC) of the National Academy of Sciences (NAS) on Aug. 19, 1992 released its report titled "Science and the National Parks," and set off a flurry of activity within the Park Service. Director Ridenour convened a field managers' task force on Sept. 24-25, to develop options for the NRC report's top recommendations. Task force members included Gene Hester, Bob Baker, Stan Albright, Bob McIntosh, Tom Ritter, Dale Engquist, Dave Mihalic, Rob Arnberger, Don Falvey, Ralph Tingey, Cindy McCleod, Jim Larson, and Jim Sherald.

Director Ridenour participated extensively in the group deliberations and the task force presented its options to him on September 25. The Director sent a memo on Oct. 7, 1992 to the ADs for Natural Resources and Budget and Administration, the AD for Legislative and Congressional Affairs, and the Director of the Office of Policy, directing them to implement several of the NRC report recommendations in accordance with the options identified by the field managers' task force.

Specifically, Director Ridenour authorized that a "Research in the National Parks" bill be drafted and submitted to Congress by Jan. 15, 1993 that would establish a mandate for science in the NPS. The recommendation to seek a strategic funding increase for science will be addressed by first completing a Servicewide assessment and quantification of need no later than Sept. 30, 1993. Meanwhile, the FY 95 budget call will handle science needs, using the interim data base that also was utilized for the FY 94 budget formulation. The Director ordered that the controversial recommendation to create an independent science arm in the Service be dealt with by adopting what had been termed the "Western Region" model of research supervision and program management. Specific recommendations for organizational changes needed to accommodate this significant action were due to the Director by Dec. 31, 1992.

The Service will delay final decision on hiring a Chief Scientist of national repute until after necessary role and function statements and organizational structures are identified and accepted. In the interim, Dr. Hester has been authorized to proceed with filling a "Visiting Senior Scientist" position to help with these actions.

Support was given to establishing a "parks for science" program, a competitive research grants program, and a basic resource information system for the Service. The NRC recommendations to create an independent line item in the budget for research funding and to create an independent science advisory board were not accepted for a variety of reasons, but the underlying objectives will be attempted by alternati

***Denny Fenn,** Deputy AD, Natural Resources*

REGIONAL HIGHLIGHTS

Mid-Atlantic Region

The Region welcomes several new Resource Managers: Denise Cook, formerly superintendent of Natural Bridges National Monument, joins the Regional Office staff as a Natural Resource Manager responsible for air, water, and rare and endangered species; Ken Stevens, formerly Resource Specialist at Bandolier National Monument, is the new Resource Manager at New River Gorge National River; and Carl Zimmerman, formerly Resource Manager at Gulf Islands National Seashore, is the new Resource Manager at Assateague Island National Seashore.

The Region's resource managers met at Virginia Tech last spring to discuss regional resource management issues and RMPs, followed by a Social Science Short Course that examined the application of social science to park management. Topics included carrying capacity, visitor management, tourism, park economic impact, and park neighbors.

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Virginia Tech CPSU Leader Jeff Marion participated in an international workshop on visitor carrying capacity, held in Belize, Central America and sponsored by the World Wildlife Fund. He gave a paper, "Tourism impacts to protected areas: Procedures for the development of monitoring programs," and took part in a panel on similar topics at the First World Congress on Tourism and the Environment, also held in Belize.

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Copies of 2 papers presented to the Northeastern Recreation Research Conference, "Trail inventory and assessment approaches applied to trail system planning at Delaware Water Gap NRA" and "Campsite impact management: A survey of NPS backcountry managers" are available from Jeff Marion at NPS/CPSU, Virginia Tech/Dept. of Forestry, Blacksburg, VA 24061-0324.

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The Region has established Geographic Information System technical support agreements with Penn State University and NC/State University. The 2 schools will help the Region's parks develop and operate ATLAS-GIS and GRASS-based GIS programs. NCSU recently hosted a regional planning session attended by Regional Office, park, and university staff, to begin development of a work plan.

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Intensive long-term research conducted by U/VA scientists has documented the acidification of streams in Shenandoah NP. Acidity levels are approaching the biologically critical level of 6.0 in 1 stream and have exceeded this level in another. Chronic acidification has been documented from analysis of weekly samples from these streams, beginning in 1979. A significant new research program to record, analyze, and predict biotic responses to the acidification has begun. An integrated multidisciplinary analysis of chemical/biotic linkages will be used to examine fish community responses to stream acidification.

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Research to develop I&M protocols for vertebrate surveys in parks has been initiated at Penn State U. This research will evaluate existing literature, develop or modify existing I&M protocols, and field test recommended protocols on selected MAR parks. Protocols will be organized by management information needs: presence/absence, relative abundance, and species distribution.

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Two Mid-Atlantic Region employees recently took part in an exchange with Russian NPs through a joint effort of the NPS Office of International Affairs, Delaware Water Gap NRA, and the Student Conservation Association. Maria Burks, superintendent at Fredericksburg and Spotsylvania County Battlefields National Military Park, and Elizabeth Johnson, Chief of Research and Resource Planning at Delaware Water Gap, traveled to Vodlozero NP to assist with park planning, development, and operational issues. The newly created park encompasses 1.5 million acres of rivers, lakes, bogs, and virgin forest within which are hidden the remnants of historic and prehistoric civilizationsd of both the Karalia and Archangelsk regions of Russia (bordering Finland).

Pacific Northwest

"The contribution of sociology to biodiversity research and management" is the title of an article in **Biological Conservation** (1992, **62**, 161-170), by Gary E. Machlis, NPS/CPSU at U/ID in Moscow, ID and professor in the departments of Forest Resources and Sociology. Like all scientific and environmental issues, Machlis notes, biodiversity is partially a socially constructed problem. Case study and comparative multinational data suggest that the causes of biodiversity decline are a largely socio-economic, and solutions will require interdisciplinary approaches. The paper discusses how sociology can make contributions to biodiversity research and management, including (1) better understanding and management of habitat change; (2) improved research and decision-making methodologies; (3) development of a theoretical synthesis; and (4) analysis of the social organization of conservation and conservation biology.

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An expansive exhibit on the discovery of fossils and the ongoing management of paleontological resources of John Day Fossil Beds NM is on display this year at the High Desert Museum 6 miles south of Bend, OR. Recent finds at John Day include a new rodent, the size of a modern ground squirrel; a mouse-deer and two canid species, including one that may represent a new species.

A new dating procedure, being used at the Berkeley Geochronology Center in California, shows promise of being able to date prehistoric samples of volcanic tuff to an accuracy of within 100,000 years. This methodology (called the single-crystal laser fusion argon/argon method) should help paleontologists like Ted Fremd (at John Day) figure out how all the species being found fit together chronologically.

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A 5-year effort to evaluate the potential for the Cascade Range of Washington to support a viable population of grizzly bears has concluded that a probable population of 10 to 20 bears does inhabit the Cascades. Numerous sightings and observations of tracks have occurred, and a GIS evaluation of habitat has led the USFWS to determine the population is "recoverable." With the Washington Dept. of Wildlife as the lead, the USFS, NPS, USFWS, and the Government of British Columbia are working together in this project as a subgroup of the Interagency Grizzly Bear Committee.

For more information, contact Kathy Jope at (206)553-5670.

National Capital Region

The Region recently joined with the Michigan State University Pesticide Research Center and the MI/State/U Foundation in sponsoring the 1992 International Dutch Elm Disease workshop, "Recent Approaches to the Dutch Elm Disease Problem." The last Dutch elm disease conference was held in 1981; in the interim, considerable progress has been made in cellular and molecular approaches to understanding and controling the disease. The workshop brought together from around the world old and new generations of Dutch elm disease researchers, so that acquaintances could be made and both old and new information shared.

Forty-five participants from 6 countries attended. Sessions covered conventional approaches to disease management, principally breeding for resistance; application of the pathogen toxin to elm tissue cultures for rapid selection of resistant trees; and molecular approaches for characterizing the host and the pathogen. Workshop proceedings will be published.

Awards were presented by Dr. Gordon Guyer, president of MI/State/U, to 3 retired researchers: Dr. Hans M. Heybroek, Institute for Forestry and Nature Management Research, Wageningen, Netherlands; Dr. Richard Campana, Department of Botany and Plant Pathology, University of Maine; and Dr. Francis W. Holmes, Shade Tree Lab, University of Massachusetts. Each award was an inscribed plaque made from a cross section of a limb of the 165 year old Adam's Elm, removed from the White House grounds in 1991. The agencies sponsoring the workshop received similar plaques.

The National Capital Region and MI/State/U are working through a Cooperative Agreement on molecular and biochemical aspects of Dutch elm disease management. Dr. Mariam B. Sticklen of the MI/State/U Pesticide Research Center, and Dr. James L. Sherald of the National Capaital Region's Center for Urban Ecology, are program managers.

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REGIONAL HIGHLIGHTS

Western Region

A review was held in Tucson, AZ Sept. 1-4, 1992 to evaluate the Saguaro NM air quality biological effects research program. The review's evaluation and recommendations will assist in establishing the direction for air quality research at the monument. Copies of the report may be had from the NPS CPSU, U of AZ, (602)670-6885.

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The following reports have been published by the CPSU at U/AZ:

Tech Rpt #46, "Status of non-native plant species, Tonto NM, AZ, by B.G. Phillips.

Tech Rpt #47, "Mammals of the woodland and forest habitats in the Rincon Mountains of Saguaro NM, AZ," by Russell Davis and Ronnie Sidner.

Tech Rpt #48, "Case study of research, monitoring, and management programs associated with the saguaro cactus (*Carnegia gigantea*) at Saguaro NM, AZ" byJoseph R. McAuliffe.

These reports or a complete publication listing may be had by contacting the CPSU at U/AZ, (602)670-6885.

Water Resources Divison

The Water Resources Division has moved to a new location: 1201 Oakridge Drive, Suite 250, Fort Collins, CO 80525; (303) 495-6200.

Southwest Region

Other agencies are continuing to "get the word" about Integrated Pest Management. Jerry McCrea, REgional Biologist, recently sent a "start up" package about IPM to the Lower Colorado River Authority in Austin, TX. Earlier in the year, he sent a similar package to the Texas Parks and Wildlife Dept.

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The Africanized honey bee (AHB) continues to be in the news. Padre Island National Seashore was the third park in the region to have a confirmed identification. The park staff successfully removed the colony from a park structure after removing some of the siding from the building.

The staff has recently participated in the regional workshop on the AHB, which included hands-on training in an apiary. The course was conducted in August, 1992 in San Antonio; 17 SWR personnel attended. Dave Vekasy of San Antonio Missions NHP was course co-coordinator.

Education is a key tool in AHB management. An article on the subject, written by the Regional Biologist, was published in *Contact*, the Southwest Region's interpretive newsletter. An information package, which contained the article, was prepared and distributed at the regional IPM coordinators' meeting in September 1992 in WASO.

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Museum IPM was the subject covered in a workshop co-sponsored by the Midwest and the Southwest Regional Offices. This course, the inspiration of Steve Cinnamon of MWRO, was held at Haskell Indian Junior College in Lawrence, KS Aug. 31-Sept. 4, 1992. Our course was the first NPS class to be conducted at this DOI training center...a nice facility that others may want to consider as a training site. Twenty-four NPS personnel attended, representing 24 parks and 4 regions (MWR, SWR, PNR, and RNR).

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The Regional Biologist recently attended a multi-agency noxious weed meeting convened by the State of New Mexico and held in response to the 1990 Farm Bill's noxious weed provisions as well as to a memorial passed by the NM legislature. The thrust of the meeting was to encourage private landowners to manage noxious weeds, thus helping to reduce weed pressure on public lands. Four working groups were established with these objectives: (1) review of a draft noxious weed list, (2) investigation of educational opportunities, (3) weed mapping, and (4) identification of funding options. The Southwest Region is on the education working group.

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The CPSU at Albuquerque is installing a Community GPU Base Station for use by nearby parks. The post-processing of GPU data increases accuracy of field observations and will complement field activities in numerous NM parks.

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El Malpais National Monument (ELMA) is the center of some wildlife management activity. The BLM recently declared its desire to introduce bison adjacent to the monument, where the animal is not native. The animals are currently on Fort Wingate, in western NM; the base is scheduled for closure. The SWR's Division of Environmental Coordination and Division of Natural Resources Management and Science worked together closely to present the case for why NPS policy would not support such an action. BLM's response is pending.

El Malpais is one of 2 SWR parks being studied by the NM Dept. of Game and Fish as possible reintroduction sites for bighorn sheep. Bandelier National Monument is the second site. In the case of ELMA, a particularly interesting aspect of the stody is that bighorn tissue is preserved in one of the park's caves, which will allow DNA testing to determine whether the desert or Rocky Mountain subspecies was native to the park. ELMA is one of only 4 areas where bighorn were known to inhabit lava flows. Native Americans report hunting bighorn in the area as recently as the 1950s.

North Atlantic Region

Paul A. Buckley, NPS Senior Scientist at the Coastal Research Center, University of Rhode Island, is the author of an invited chapter in the recently published book, *Wildlife 2001: Populations* (1992 Elsevier). The paper, "Modeling Metapopulation Dynamics for Single Species of Seabirds," is the first application of this new approach to population dynamics in seabirds using stochastic models known as RAMAS/space and RAMAS/stage. Generic albatrosses, cormorants, and terns were modeled, with unexpected and provocative results. Metapopulation modeling will be of increasing importance in grappling with the problem of fragmented populations in national parks and their environs.

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Two new regional resource management specialists have joined the North Atlantic Region. Leslie Pointer moved from Chief of Resource Management at Yosemite to become Branch Chief of Resource Management; Susan Alberts is the new IPM Coordinator.

Bruce Connery also has jointed the Acadia NP resource management staff as the I&M Coordinator.

Jim Allen, Coastal Geomorphologist, and scientists from Rutgers University and the University of Southern California conducted a highly instrumented study of bayside beach erosion and sediment transport at Fire Island National Seashore with funding from NSF and NPS. He also helped SWRO develop a plan for recreational use of the eroding Laguna Madre beach at Bird Island Basin, Padre Island National Seashore.

Southeast Region

In the days immedidately following Hurricane Andrew, the NPS assembled a professional resource assessment team to measure the ecological "vital signs" of south Florida national parks. Twenty-three scientists from a variety of disciplines examined resource conditions in order to prescribe immediate actions to stabilize threatened resources and identify long-term activities to assure continued health of park ecosystems. They examined the geographic limits and impacts of storm influence on coral reefs, seagrass beds, hardwood hammocks, mangrove forests, sawgrass marshes, pine forests, historic shipwrecks, and archeological sites. They also determined the status of endangered species such as panthers, crocodiles, and bald eagles. Air and water quality and organic debris and sediments that shape biological communities were studied.

A final executive summary of the report is available; the full report will be published after peer review is complete.

Team members included the following:

Resource Assessment Coordination: Gary E. Davis (Assessment leader), Laurie Parker, and Cameron Shaw.

Marine Resources: James Tilmant (Teach leader),. Richard W. Curry, Jay Zieman, Ronald Jones, Thomas Smith, and Alina Szmant.

Freshwater Resources: Charles T. Roman

(Team leader), Joel Trexler, Mark Flora, Nicholas Aumen, James Schortemeyer, Robert Fennema, and Ben McPherson.

Upland Resources: Lloyd L. Loope (Team leader), James Snyder, Mike Duever, and Alan K. Herndon.

Archeology: George Smith (Team leader), Larry Murphy, Guy Prentice, and John Cornelison.

GIS: Donald Myrick and Michael Rose.

Peer Review Group: Michael Soukup, William B. Robertson, Jr., Ariel E. Lugo, Stuart L. Pimm, Robert Ulanowitz, John Ogden, and Peter Glynn.

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The South Forida Water Management District, the Florida Dept. of Environmental REgulators, U.S. Justice Dept., and agricultural parties have agreed to the use of an outside mediator in the ongoing lawsuit regarding the Everglades restoration program. The mediator would work with the groups involved to try to reach consensus on the restoration program.

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The GIS Specialist in the Southeast Region has been relocated from the regional office to Clemson University in South Carolina. Neil Guse, Clemson CPSU Director, will be serving as program coordinator for GIS and will supervise the GIS Specialist position.

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Through a project funded jointly by NPS, the U.S. Army Corps of Engineers, and the South Florida Water Management District, a native Australian insect is being studied as a biological control agent for the Melaleuca tree. The weevil *Oxyops vitiosa* has been quarantined at the USDA Agricultural Research Center in Gainesville, FL, where it will be tested to insure that no natiove plant species would be adversely affected by its dispersion.

Melaleuca, recently designated as a noxious weed by the USDA, displaces wetland vegetation and wildlife habitat and has had adverse effects in the Big Cypress National Preserve and Everglades NP.

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Personnel chanages in the Office of Science and Natural Resources:

Through a cooperative agreement with The Nature Conservancy, a database manager has been hired for the Region's Biological Conservation Database. The comprehensive computerized database tracks information on plants and animals, focusing on rare and threatened species. Clifton Eakes began in this position in November. His most recent previous position was Natural Areas Specialist for the Mississippi Natural Heritage Program

Bob Hickman has joined the Regional office staff as resource management plan coordinator, publications coordinator, and project management coordinator. He has 20 years or experience in the North Atlantic, Midwest, and National Capital Region parks.

Brendhan Zubricki was hired to fill the vacant air/water quality coordinator position for the Region. Brendhan worked for the CPSU at U/RI on water quality issues.

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Recently published technical reports include:

Claxon, P.G. and H.L. Renwick. 1990. Bibliography of Scientific Research for Gulf Inslands National Seashore. CPSU, Rutgers- The State University of NJ. NPS/SER/93-01.

Claxon, P.G. and H.L. Renwick. 1990. History of Scientific Research for Gulf Islands National Seashore, CPSU, Rutgers-The State University of NJ. NPS/SER/93-02.

McCracken, G.F., C. Parker, and S. Guffey. 1992. Genetic Differentiation and Hybridization between Hatchery Stock and Native Brook Trout in Great Smoky Mountains NP. NPS/SER/93-05

Rikard, M. 1991. A Water Quality Study at the Congaree Swamp National Monument of Myers Creek, Reeves Creek and Toms Creek.NPS/SER/93-06.

Midwest Region

New faces and/or positions in the Region:

Sue Jennings transferred from Blue Ridge National Parkway to a Resource Management Specialist position at Saint Croix National Scenic Riverways; Sam Lamie has entered government service as a Cartographic Technician at Voyageurs NP; Ed Childres transferred to Indiana Dunes NL as a Cartographic Technician from the Soil Conservation Service; Joe Myer has transferred from the SER to serve as Regional GIS coordinator at the newly established GIS Regional Technical Support Center at the Great Lakes CPSU, U/WI, Madison; Bob Manasek has become Resource Management Specialist at Scotts Bluff National Monument; Bob Brander, formerly Apostle Islands NL ecologist, has accepted a term appointment as Great Lakes Coordinator.

New to the Research staff at Indiana Dunes NL are Dr. Paul M. Stewart, aquatic ecologist, and Dr. Ralph Grundel, animal ecologist. Stewart was on the staff at Indiana U/Purdue U at Fort Wayne; Grundel was on the staff at U/CA, Berkeley.

Stewart has been appointed scientific liaison in cooperation with the USFWS to examine sites along the St. Croix for zebra mussel infestation and to recommend measures to retard its spread in the river basin.

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Dr. Richard Whitman, Chief Scientist at Indiana Dunes NL, has been appointed to the U.S. Great Lakes Policy Committee, which will address the 5-Year Strategic Plans for the Great Lakes. As a result of last year's Environmental Roundtable meeting, a resolution was signed by 13 Midwest states and federal agencies on interagency cooperation. Whitman is team leader for a working group on Interagency Research Needs Assessment for Environmental Management.

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The Region has finished a draft publications plan outlining a strategy for establishing 3 series and for designing review procedures and standards. The plan is available for review by other Regions; please contact the Regional Chief Scientist if interested.

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A 2-day training session, held at Sleeping Bear Dunes Sept. 15-16, 1992, addressed dune systems management issues in the Great Lakes. Staff from Sleeping Bear Dunes, Indiana Dunes, and Pictured Rocks attended together with nearby staff from both State and Federal agencies.

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Dr. Richard Whitman, Indiana Dunes NL Chief Scientist, presented a paper, "Composition, spacial-temporal distribution and environmental factors influencing the interstitial beach meiofauna of Lake Michigan" at the XXV SIL International Congress in August 1992 in Barcelona, Spain. The paper, authored by Whitman, Kevin Kennedy, and Mary Andrzejewski, has been submitted for publication to Vereinigung Fur Theoretische und Angewandte Limnologie. Whitman gave a related paper at the 8th International Meiofauna Conference in Washington, DC, also in August.

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The following papers by Indiana Dunes staff have been accepted for publication:

Bowles, M.L., R. Flakne, A.K. McEachern, and N.B. Pavlovic. In Revision. Status and restoration planning for the federally threatened Pitcher's thistle (*Cirsium pitcheri*) in Illinois. **Natural Areas Journal**.

Brown, J.S. and N.B. Pavlovic. 1992. Evolution in heterogeneous environments: Effects of migration on habitat specialization. **Evolutionary Ecology** 6:320-382.

Cole, K.L., K.F. Klick, and N.B. Pavlovic. 1992. Fire temperature monitoring during experimental burns at the Indiana Dunes. **Natural Areas Journal** 12: 177-183.

McEachern, A.K., M.L. Bowles, and N.B. Pavlovic. In Press. Recovery planning for the threatened Great Lakes thistle *Cirsium pitcheri* according to a metapopulation model. In Bowles, M.L. and C. Whelan (eds). **Recovery and Restoration of Endangered Species**. Cambridge U Press, Cambridge, MA.

Pavlovic, N.B. In Press. Disturbance-mediated persistence of rare plants: restoration implications. In: Bowles, M.L. and C. Whelan (eds.) **Recovery and Restoration of Endangered Species**, Cambridge Press.

Pavlovic, N.B., M. DeMauro, and M.L. Bowles. 1992. Perspectives on Plant Competition--Plant collection rate should be positively correlated with plant population size: Reply to the 1-in-20 rule for plant collection. **Plant Society Bulletin** 38(1):8.

Whitman, R.L., D. Fagre, N. Pavlovic and K. Cole. 1992. Applications of Landscape Ecology to Urban Park Management. U/MA Press.

MAB Notes

The Sonoran Institute recently sponsored a regional forum on "Land Use Changes in the Western Sonoran Desert Border Area." The 150 participants--including representatives from U.S. and Mexican agencies, the Tohono O'oodham Nation, and citizens from local communities--met in Ajo, AZ in October and reviewed major resource issues facing the region, including the implications of the North American Free Trade Agreement. The "town hall" approach was an outgrowth of discussions over the past several years to consider ways to implement the biosphere reserve (BR) concept in this multi-cultural region.

The possible imminent establishment of a large BR in the Pinacate-Gran Desierto area of Sonora (adjacent to the Organ Pipe Cactus NM BR) provides incentive and opportunities for strengthening transborder linkages among BRs.

Bill Gregg addressed the forum on cooperative approaches to coping with borders. In his keynote, Hubert Hinote, Executive Director of the Southern Appalachian MAB Cooperative, discussed the experience of the Southern Appalachians in organizing cooperative projects to meet regional needs. The forum resulted in a consensus on the need for improved mechanisms for trinational cooperation in generating and sharing information on regional issues, and a recommendation for follow-up assessment to see how this could be accomplished.

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In September, the International Union of Forestry Research Organizations, in cooperation with U.S. and Canadian agencies and organizations (including the NPS) sponsored an international symposium on "Ecology and Management of Larix Forests." The symposium drew participants from more than a dozen nations and provided a comprehensive review of the state of knowledge of the ecology, genetics, and management of Larix forests, which occur in boreal and alpine environments throughout the northern hemisphere.

Gregg and Pat Halpin (U/VA) gave a poster, focusing on opportunities for cooperative research in BRs. The poster identified 20 BRs containing one or more species of Larix, and included results of potential life zone shifts in Larix BRs, based on various global circulation models. Gregg and Stan Krugman, BR coordinator for the USFS, co-chaired a seminar on BRs, emphasizing the ongoing small watershed research program in BRs in the U.S. and the former Soviet Union, and the EuroMAB biological inventory database.

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The EuroMAB pilot project to prepare biological inventory databases in BRs is underway. The project was finalized at a July meeting of MAB representatives from countries participating in the *Biosphere Reserve Integrated Monitoring Program,* which Mike Ruggiero attended. The formats for the NPS Biological Inventory Status (BIS) and the biological inventory (NPFLORA and NPFAUNA) databases were adapted for use in EuroMAB BRs. The formats are being used to prepare pilot BIS and vertebrate inventory databases for a selected BR in Canada, the Czech and Slovak Federated Republic, France, Germany, Russia, Rumania, Spain, Sweden, the United Kingdom, and the U.S. The MAB Secretariat has sent each country instructions for preparing the databases, which were scheduled to be returned to USMAB by the end of 1992. The experience of preparing the pilot databases will help EuroMAB countries determine a future strategy for preparing and managing biological inventory data from BRs.

Bill Gregg, *MAB Coordinator,NPS Washington Office*

Rocky Mountain Region

The Region has joined the Colorado River Endangered Fishes Recovery Implementation Program. Four endangered and 2 candidate species are the subject of considerable effort to stave off extinction: razorback sucker, bonytail chub, humpback chub, and Colorado squawfish are endangered; roundtail chub and flannelmouth sucker are candidates. Ed Wick of our Fort Collins office has the lead in this effort.

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Anthropological field research projects have begun in Glacier NP and in the Bighorn Canyon NRA. These are the first systematic efforts to collect baseline data on ethnographic resources within these park units. Dr. Brian Reeves (U/Calgary) and Dr. Larry Loendorf (Loendorf and Assoc.) will work closely with park staffs and members of the Native American community presently using park resources for traditional cultural purposes The results will provide information on present use of natural resources within these parks and a cross cultural perspective on resource values to inform the development of natural resource management options.

* * *

In honor of its 20th anniversary, Fossil Butte National Monument in 1992 hosted the Third Conference on Fossil Resources in the NPS. The 2 previous conferences were held by Dinosaur National Monument and Petrified Forest NP. Conference topics have dealt with paleontological issues such as promoting paleontological research in NPs, increasing NPS technical staff, fossils in the field, laboratories and museums, interpretation, law enforcement issues including theft and vandalism, and paleontological issues outside the Park System.

Final products of the 1992 conference are a technical report including abstracts, selected papers and a field trip guide, and a letter to the NPS Director describing the status of NPS fossils and recommendations for future actions. The Fourth Conference on Fossil Resources is planned for 1994 and will be hosted by Florissant Fossil Beds National Monument.

Limburger Cheese Attracts New Species To Pit Traps at Oregon Caves

Compared to most surface environments, caves tend to be low energy/low food environments. They usually lack much wind, light, freeze-thaws, or organics; thus it is fragile minerals and species with low metabolisms that normally thrive underground. Foot traffic, lights, clothing lint, tunnels, and vandalism are high/energy/food impacts on caves. Visitors or altered airflow bring in skin flakes, dust, spores, or detergent-rich lint, all of which foster exotic plant growth.

In Oregon Caves, Carlsbad Caverns, and probably many other commercialized caves, exotic animal communities have developed on lint deposits and exotic plants. Studies in Carlsbad Caverns and Mammoth Cave indicate that an unnatural increase in food causes the "paradox of enrichment," where surface-adapted insects move in and outcompete smaller and slower moving cave-adapted insects. The extinction rate from these impacts depends in part on whether caves are evolutionary "islands" or whether most of the recruitment of species occurs from small cracks surrounding the cave. Finding out which of these biogeography models best applies to cave communities is a hot topic of current biospeleological research.

Year-round baselines are needed to understand the evolution of cave communities and human caused impacts on them. Unfortunately, until a few months ago, all that was known about Oregon Caves' fauna were records such as "small white spider seen in Neptune's Grotto." The first macroinvertebrate survey of Oregon Caves began in late August 1992. Eighteen pit traps were placed in the cave to help determine the effects of cave entrances, humidity, and nearness to the cave trail on cave populations and species composition.

The use of limburger cheese as an attractant already has yielded some 20 species, at least 2 of which are undescribed and are among the most restricted endemics in the Park System. The first endemic is in the genus *Speoseya*, a millipede genus known by only 2 other specimens. The second is a water mite which probablyh is parasitic on an unknown animal. The traps are sampled and reset every 20 days. This will continue until summer 1992, when the program will be tied to a 5-months-long Earthwatch project.

John Roth, *Resource Management Specialist, Oregon Caves National Monument*

Support Tools for I&M Decision-making: Moving from the Ideal to the Real

By June C. Rugh and David L. Peterson

Editor's Note: This article (the second in a series of two) represents a research effort on the part of the Pacific Northwest Region to offer an approach for developing a dynamic, technically rigorous inventory & monitoring program within each park. Based on state-of-the-art methods and analyses, it offers practical strategy and support tools that will facilitate I&M program development among parks.

With the help of the interdisciplinary planning team described in the previous article (*Park Science*, Fall 1992), most parks will be able to develop a broad inventory and monitoring (I&M) "ideal" plan that encompasses a diversity of projects. However budgetary and personnel constraints mean that decisions must be made about the relative value and feasibility of various projects within the overall plan. This is a complex process involving a wide range of issues and hundreds of individual decisions; lacking a systematic approach, many of those decisions may be made with limited knowledge or by intuition alone. The support tools discussed here--the Analytic Hierarchy Process and supporting software, Expert Choice1--are the core of a new analytical framework for I&M planning, providing both strategic and technical support for resource managers.

The Analytic Hierarchy Process (AHP) is a structured approach to decision-making that allows resource managers to incorporate a large number of criteria and judgments *including* those based on experiential knowledge or intuition. Decision-makers are able to weigh the contributions of each option and arrive at a final assessment (or priority) that is both consistent and defensible. Applied to I&M program development, this approach focuses on three specific steps: (1) Identify I&M projects; (2) Prioritize projects; and (3) Maximize total I&M program value over all projects.

First, decision-makers identify potential I&M projects that would fulfill program objectives. Second, these projects are prioritized based on their total contribution to the I&M program goals. AHP is used as a systematic technique to determine those priorities, which represent the definable *value* each project brings to the program as a whole. Third, budget and personnel limitations are worked into program planning in order to maximize the total I&M program value over all implemented projects.

Park personnel need not be familiar with the technical details of the AHP and related software; the regional I&M coordinator would operate the software, working with resource managers to derive model inputs and evaluate model outputs. However some conceptual background can clarify AHP's role in I&M planning. The principal ideas of AHP are (1) the use of *hierarchies* to structure decision-making, and (2) the application of *judgement measures* and *formal mathematics* to express and quantify individual preferences.

As a basic paradigm, the hierarchy is particularly useful because it is stable, resisting disruptions; it accommodates additions easily; its components can be arranged in a modular fashion, allowing efficient modifications, and finally, the hierarchy is capable of incorporating a large number of elements economically.

To construct a hierarchy, a primary goal is placed at the top. For example, the *goal* in Figure 2 is to choose the most desirable car; the *criteria* for this decision are initial cost, maintenance costs, fuel costs, resale value, status, comfort, and reliability. (Additional tiers of *subcriteria* would be added in a more involved case.) *Alternatives* are the actual car models being considered and compared: VW, Honda, Chevy, and Cadillac.

Pairwise comparisons among hierarchy elements at any level provide a ratio scale ranking of these elements. First, the main criteria are compared with respect to the goal. Here, personal judgment comes into play; the decision-maker enters judgments as to the relative value of initial cost vs. maintenance costs, initial cost vs. resale value, and so on. Thus, the initial cost might be judged to be moderately more important than maintenance costs.

The next step is to compare the alternatives with respect to each criterion; the user records judgments for VW vs. Honda with respect to initial cost, and so forth. Throughout this process, the more subjective elements such as intuition, experience, or personal preference

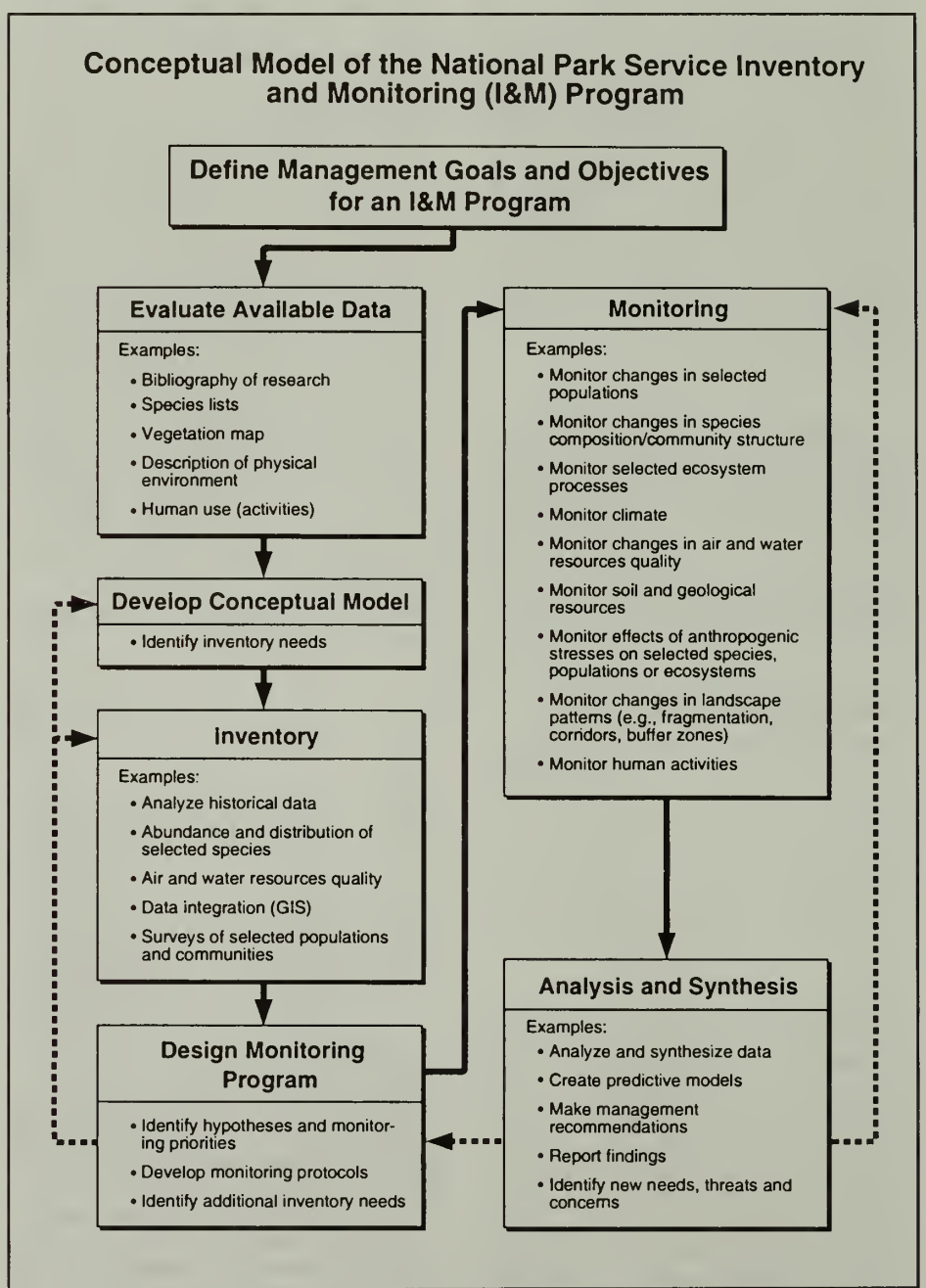

Figure 1 Conceptual overview of the inventory and monitoring process in natural park areas.

NPS-75: Guideline For the Service

Support Tools ...cont'd from p. 22

By Gary Williams

In September 1992, The NPS issued **Natural Resource Inventory and Monitoring Guideline (NPS-75)**, a document developed by the A/D for Natural Resources to provide Servicewide policy, guidance, and direction to parks designing and implementing comprehensive natural resource inventory and monitoring (I&M) programs. NPS-75 represents official NPS policy and I&M efforts at all NPS organizational levels should be consistent with guidance provided in that document.

The NPS-75 guideline is largely conceptual in nature. It is not, and was not designed to be, a "how to" manual. Rather the I&M Program National Committee, which guided NPS-75 development, determined that technical protocols on how to implement specific steps of the I&M process should be developed independently over time and provided in the form of supplements to NPS-75. The Prototype Monitoring Park component of the Servicewide I&M Program represents one major effort designed to develop those protocols in a scientifically valid and expeditious manner.

In this and a previous article published in the Fall 1992 issue of *Park Science* (pp 1-4), June Rugh and Dave Peterson offer some conceptual ideas on how an I&M program might be planned and implemented by individual parks. In several respects, their ideas parallel and complement the I&M project planning and development process outlined in NPS-75 (Fig. 1). For example, whereas NPS-75 suggests a Science Advisory Team as an effective way to develop an I&M program for a given park, Rugh and Peterson promote the use of Regional interdisciplinary teams. There is no reason those could not be essentially one and the same.

Regarding the identification of individual I&M projects, Rugh and Peterson advocate the use of "brainstorming sessions" whereas NPS-75 suggests a structured, step-down process might be used. Lastly, in their current article, Rugh and Peterson describe how the Analytic Hierarchy Process might be used to prioritize individual I&M projects to insure consistence with established park goals and objectives. Guidance in NPS-75 is much less quantitative but recommends that a risk analysis involving an assessment of the nature of resource threats and the vulnerability of resources to human-induced impacts be an important basis for establishing monitoring priorities and objectives.

There are no universal techniques for I&M efforts related to total ecosystem management. Many different ideas and approaches need to be tested. Readers should realize that the ideas provided in these articles describe a research approach being field tested in the Pacific Northwest Region for implementing the guidance provided in NPS-75. As the Servicewide I&M Program progresses, additional approaches will likely be field tested elsewhere in the Service as well.

Williams is Director of the Servicewide I&M Program at WASO.

are as systematically quantified as objective factors such as cost. With sets of these pairwise comparisons, a ratio scale emerges that captures the priority of the related elements with respect to the comparison criteria.

Further options, such as combining judgments concerning several criteria, are available as well. Figure 3 illustrates the AHP as applied to the process of rating I&M projects.

When applied to I&M planning, AHP would enable managers to define criteria for priorities in a straightforward yet versatile way. For example, priorities may be set for part of an I&M plan based on economic and biological factors. The biological factors may be subdivided into several subfactors, such as endangered species status, susceptibility to air pollution, and geographic distribution. Each of these subfactors can be further divided into yet another set of subfactors for a finer resolution. This hierarchical process can continue for many levels to include all possibilities that should be considered, with rankings assigned to each level of the process.

The linkages become complex after only a few levels and cannot be tracked efficiently with pencil and paper. For this reason, AHP has been incorporated in the software package Expert Choice[1]. This software allows the user to apply hundreds of qualitative and quantitative assessments simultaneously to establish linkages and calculate final priority rankings quickly and accurately. It also enables a resource manager to explore the nature of decisions used in the I&M planning process.

The knowledge database created can be changed or updated at any time, making it an exemplary tool for I&M decision-making. Moreover, the model can accommodate any agenda the park might wish to include. This is particularly pertinent to resource management planning by federal agencies, which often requires consideration of political issues.

Most important, AHP/EC does not *make* decisions for managers, but instead *facilitates* the process of decision-making. By providing a framework in which I&M and resource management planning issues can be addressed and quantified explicitly, these tools offer resource managers unprecedented decision-making power, versatility, and accountability.

When allocating resources within I&M program planning, the goal is to do the most I&M work possible within established budget and personnel limitations, with "most" defined as the greatest total program value. This means that an individual project's value to the program alone can determine the most effective

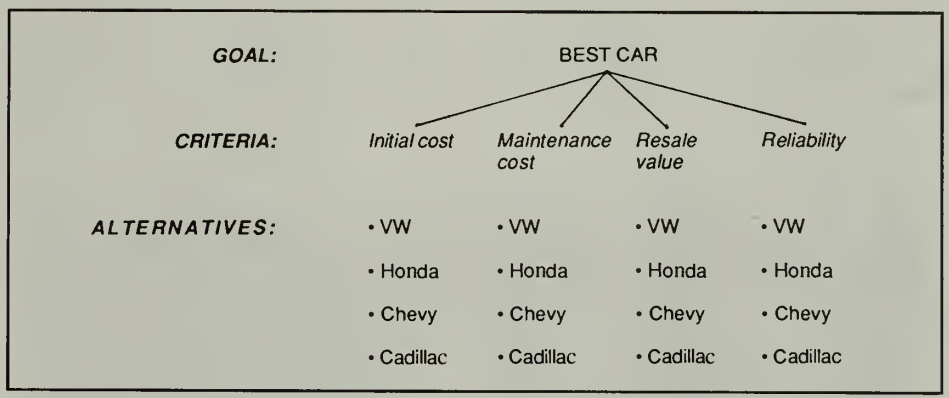

Figure 2. Choosing the Best Car: An illustration of the Analytical Hierarchy Process

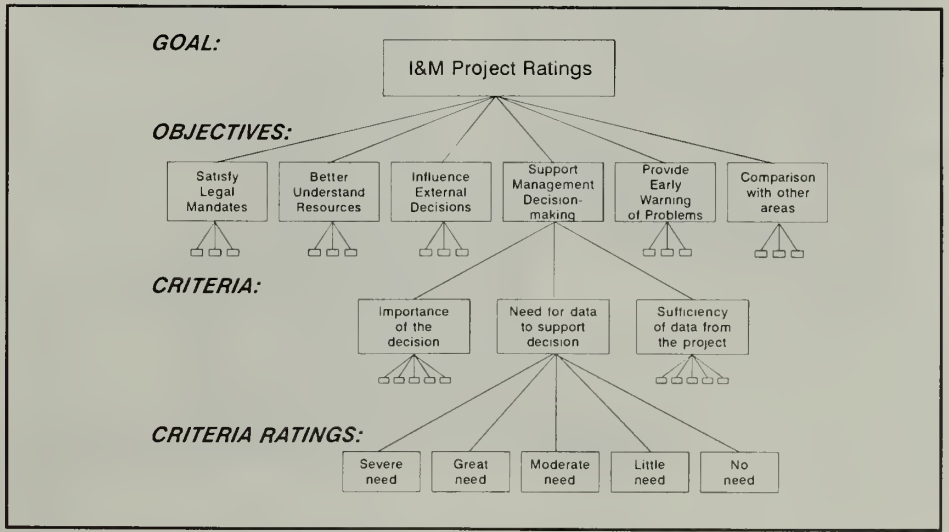

Figure 3 Rating I & M projects using the Analytical Hierarchy Process

Support Tools. . .
Cont'd from page 23

allocation of resources. Similarly, a cost-benefit approach--wherein projects with the best economic payoff garner the highest rankings--falls short by not including other constraints, such as personnel time.

Schmoldt et al. (1992) have formulated an integer programming model which, by combining AHP and linear programming, maximizes total program value, subject to specified constraints. With technical support from the I&M team, resource managers would enter the minimum constraints (budget and personnel limitations) into the mathematical formulation. Other constraints, such as restrictions on project timing, could be factored in as well. For example, if a particular project to analyze snow chemistry should not be performed until a geographic survey of snow has been completed, then those constraints would be added to the formulation.

As the final step in the resource allocation process, priority values estimated from the AHP exercise would be used as coefficients in the integer programming model.

As in any optimization procedure, the results of this "constrained optimization" approach will be only as realistic as the parameter values used in the calculations. More accurate budget or personnel estimates, or revised value judgments, can alter the emerging I&M program. Repeated use of this process will insure that results are acceptable and stable.

[1] **Tradenames are used for information purposes only. No endorsement by the U.S. Department of the Interior is implied.**

Rugh is a technical writer and Peterson is a Research Biologist at the U/WA CPSU, Seattle. Schmoldt is a Research Forest Products Technologist with the USDA Forest Service at Blacksburg, VA.

The following publications are available from the NPS CPSU, AR-10, U/WA, Seattle, WA 98195:

Peterson, D.L., D.G. Silsbee, and D.L. Schmoldt. 1992. Guidelines for developing inventory and monitoring plans in national parks. Manuscript submitted for publication.

Schmoldt, D.L. D.L. Peterson, and D.G. Silsbee. 1992. Strategic inventory and monitoring programs: prioritizing projects and allocating expenditures. Manuscript submitted for publication.

Silsbee, D.G., and D.L. Peterson. 1992. Planning and implementation of long-term resource monitoring programs. Environmental Monitoring and Assessment (in press).

Silsbee, D.G., and D.L. Peterson. 1991. Designing and implementing comprehensive long-term inventory and monitoring programs for NP System lands. Natural Resources. Rep. NRR-91/04. National Park Service, Denver, CO.

meetings of interest

1993

Feb. 2-5, **EXXON VALDEZ OIL SPILL SYMPOSIUM**, in Anchorage, AK. Sponsored by members of the Exxon Valdez Oil Spill Trustee Council,representing USDA, USDI, NOAA, the Alaska attorney general, and the AK Depts. of Fish and Game and of Environmental Conservation. Contact: Brenda Baxter, Symposium coordinator, U/AK, Fairbanks; 907-474-7086; FAX 907-474-6285.

Mar. 6-7. **PUBLIC INTEREST SCIENCE CONFERENCE in Eugene, OR, to address** issues relating to the interaction of science and the public policy process. Panel topics will include new paradigms for science and policy making, science and the law, and ethics. Workshops will deal with communicating to the non-scientist. Contact: Len Broberg, Dept. of Biology, U of OR, Eugene, 97403.

Mar. 24-27 **EIGHTH ANNUAL U.S. LANDSCAPE ECOLOGY SYMPOSIUM,** "Pattern and Process in Landscape Ecology" at Oak Ridge National Lab in Oak Ridge, TN. Contact: Dr. Monica G. Turner, Envir. Sciences Div., Oak Ridge Nat'l Lab, PO Box 2008, Oak Ridge, TN 337831-6038; (615)574-8282.

April 18-23 **WESTERN REGIONAL INTEGRATED CULTURAL & NATURAL RESOURCES WORKSHOP**, at Furnace Creek Ranch, Death Valley National Monument. WRO Contacts: Jonathan Bayless, (415)744-3968, and Gene Wehunt, (415)744-3957.

May 17-21 **NATIONAL INTERAGENCY WILDERNESS CONFERENCE**, Tucson, AZ. Focus on 3 stewardship themes: (1) Wilderness Restoration--minimum tool use in alien plant species control and reveg; (2) Complementary Management of wilderness and archaeological, historical, and cultural resources, and (3) Emerging Challenges: cultural diversity, demographic trends, adjacent land uses, day use, outfitter policies, and access for the disabled. Contact: Alan Schmierer, WRO (415)744-3959.

June 22-25 **CONSERVATION IN THE WORKING LANDSCAPES,** the 1993 Natural Areas Conference, at Univ. of Maine, Orono, ME. Symposia topics: Biological diversity in working landscapes (total perspective and institutional perspective), conservation in marine ecosystems, inventory and monitoring natural landscapes in working landscapes, conserving endangered species and natural communities in working landscapes, and managing natural areas in working landscapes. Deadline for papers, Jan. 15, 1993. Contact: Hank Tyler, ME State Planning Office, Station 38,. Augusta, ME 04333; (207)624-6041.

Aug. 24-26 **12th WILLIAM T. PECORA REMOTE SENSING SYMPOSIUM,** "Land Information from Space-Based Systems," Sioux Falls, SD. Sponsored by the USGS in cooperation with other federal agencies. Abstracts are due by Feb. 15, 1993. Contact: Dr. Robert Haas, Symposium chair, 605-594-6007 or Dr. James W. Merchant, Program chair, 402-472-7531, FAX 402-472-2410.

Ecological Society Meeting

Six members of the U/WA CPSU research team attended the 1992 meeting of the Ecological Society of America in Honolulu in August. Four papers presented in a session entitled "Effects of Global Climate Change on Forests," were:

Regina M. Rochefort and David L. Peterson: Effects of climate and other environmental factors on tree establishment in subalpine meadows of Mount Rainier NP;

Gregory J. Ettl and David L. Peterson: The effects of climate on growth of subalpine fir *(Abies lasiocarpa)* across elevation gradients;

David W. Peterson and David L. Peterson: Subalpine forests and climate change: a dendroecological study; and

Ronda L. Little and David L. Peterson: Effects of climate on regeneration of subalpine forests following wildfire in the Cascade Range of Washington.

An additional paper, presented in the session on Paleoecology, was by Michael J. Arbaugh and David L. Peterson: A dendroecological analysis of drought sensitivity for ponderosa pine along the Front Range of Colorado, USA.

Research Assoc. David G. Silsbee presented the results of previous air quality studies in Great Smoky Mountains NP in a poster paper, "Effects of canopy position and topographic sheltering on exposure of plants to ozone."

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Ecology of High Mountain Black Bear Population In Relation to Land Use at Rocky Mountain NP

By Henry E. McCutchen

Rocky Mountain NP in Colorado is one of the most heavily used parks in the west. It receives more visitation than Yellowstone yet is only 1/8 the size. In addition, unlike other large western parks such as Glacier and Yellowstone, which were carved out of near wilderness, ROMO was established in an area that had been heavily homesteaded, hunted, logged, farmed and grazed for over 50 years.

By 1915 when the park was established, the large mammalian fauna populations had already collapsed (Newmark, 1987) from the impact of European settlement, and they have yet to recover. The elk, once numbering in the thousands, had become extinct by the 1900s. Transplants from Yellowstone were made just before the park was established, and under park protection the herds are now flourishing. Mule deer and bighorn persisted; however bighorn numbers declined in the 1930s and required transplants to supplement lost herds (Stevens and Hansen, 1986). The wolf became extinct before 1900; the grizzly was present until the early 1920s, then it also disappeared. The two other large carnivores, the mountain lion and the black bear, were present when the park was established but occurred in low numbers.

According to historical reports (Superintendents annual reports ROMO) after the park was established, black bears were extremely scarce. By the 1930s bears were observed fairly regularly yet were still believed to be low in numbers. From the 1930s to the 1980s the bear population was thought to be stable and occurring in low densities throughout the park.

Rocky Mountain, unlike other parks with black bear populations, has not experienced large numbers of bear depredations. For example, records of bear incidents from 1959 to 1983 totaled 133 with an average of about 5 per year compared to Sequoia and Kings Canyon NP which, between 1959 and 1976, had a total of 3,968 bear incidents for an average of 220 per year (McCutchen, 1987).

In 1984 bear depredations at ROMO unexpectedly became a problem in the backcountry, reaching a record of 90. Park management found there was no information on the population, and without an idea of the population and its dynamics there was no way to predict the impacts of a management or control program. In 1985 the park began a research program on the bear's population dynamics and ecology.

The southern 2/3 of the 265,000 acre park (about 190,000 acres)--the overall study area--was dissected by the Continental Divide, forming convenient east and west study areas. The area east of the Continental Divide (90,000 acres), where most of the bear depredations occurred in 1984, receives the highest front and backcountry use. Outside the park boundary to the east is a region of intensive urban and suburban development and human use, including the gateway town of Estes Park. The study area west of the continental divide (100,000 acres) provided a good "control." It receives less visitor use and most of the area outside and adjacent to the park is undeveloped USFS land.

Rocky Mountain NP, in north-central Colorado about 50 miles northwest of Denver, preserves the most rugged section of the Colorado Front range. Elevations are among the highest in the contiguous U.S., (8,000' to 14,000'+). Vegetation zonation is apparent. About 1/3 of the high study area is alpine tundra. Mid-slopes contain spruce/fir vegetation; lodgepole pine occurs on old burns and south facing slopes. At the lower elevations, north facing slopes contain Douglas fir and aspen; glacial moraines with Ponderosa pine intermixed with meadows occur in the dryer sites. The winter climate is cold with low precipitation; summers are cool, with moderate precipitation; the alpine tundra can demonstrate arctic conditions year round.

Because black bears are difficult to count, the study aimed at a total capture census. The bears were captured with foot snares, marked with ear tags and radiocollared. The east area census took two years. Low bear densities meant that a lot of country had to be covered to capture one bear and almost all the field work had to be done in the backcountry. Baiting and capture equipment was carried by backpack.

The west side study area was censused in 1987, 1988, and 1989. Following this, radiotracking and monitoring were performed until the study was terminated in the winter of 1992.

The study was hindered throughout by funding, manpower and logistics problems. Volunteers in the Parks (VIPs) were increasingly utilized for lower risk tasks (radiotelemetry and assistance in bear capture). The park put out a call for volunteers and eventually a cadre of about 25 VIPs was available to meet project needs.

Most of the volunteers became highly skilled in radiotelemetry and bear handling assistance. The project could not have been done without them. The park staff, particularly the West Unit staff, also provided assistance and logistics support. Because of the rugged terrain the bears inhabited, it was not uncommon for a radiotracking team to spend an entire day hiking in order to get a single radiolocation on a bear. It was necessary to go to the bear dens in the winter to replace radiocollars, to obtain data for denning ecology and to check for reproduction and physical condition, which posed special logistic and safety problems. The bears tended to select cave dens near timberline, a little over 2 miles above sea level--from 10,000 to 11,000 feet, on steep north facing slopes, among cliffs, remote from human use and trails. The winter team had to snowshoe or ski, with heavy packs, coping with cold weather, high altitudes, blizzards, temperamental snow packs, steep slopes, snow covered cliffs and avalanche hazard.

Hazardous Work

Although the work was hazardous, as the winter crew gained experience with safety foremost in mind, the risk was reduced. There were minor mishaps on almost every trip - frost bite, tumbles down steep slopes, bruises and sprains,

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Author with 25 pound yearling black bear at its den in Rocky Mountain NP. The bears in the park were found to be among the smallest in North America

The bears in Rocky Mountain NP denned in caves on steep slopes, in remote areas far from roads and trails at 10,000' elevations. Radiolocating and snowshoeing to the dens was a dificult task. Research technician, BillMcEwen, clears den entrance as VIPs Damon Lamothe, Holly McCutchen and Jana McCutchen observe.

altitude sickness, and forced overnight bivouacs, but no serious injury occurred on any winter trip.

After all the census effort on the east side, only 6 adult and subadult bears were captured. Of these only 2 were adult females; 3 were subadult males, 1 was a subadult female, and 3 were cubs of the year. The study team believed that all resident bears in the area had been captured, as each was snared several times before the bears became trap wary.

Since the area had been well covered with capture sites, the study team concluded that the low capture rate was because of their low numbers. Because it had seemed logical that there should be more bears in the area, capture effort was maintained long after all the residents had been captured.

The research revealed the extremely low density of bears in this area. If 3 cubs were counted for a total of 9 bears, the density was only 1 per 16 square miles compared to 1 bear per 2.2 square miles found in the black bear research program conducted by the Colorado State Division of Wildlife in southern Colorado (Beck, 1991). About 40 percent of the east side study area was alpine habitat, which the bears did not utilize. If this area was not included and only forested habitat was calculated in relation to bear numbers, the density was 1 bear per 9.7 square miles--still a low density.

(The bear depredation problem was solved in 1985 by the capture and radiocollaring of the first subadult male, a 3-year- old. After his release his activities resulted in his recapture and transplant to a remote section of the park. He was killed by a hunter outside the park, and after his demise bear incidents in the backcountry dropped to previous low levels.)

West Area Results

The bear census on the west side study area (from 1987 to 1989), revealed a slightly better situation than the east side. Of 12 bears accounted for by 1989, 3 were adult females and 4 were adult males. Two subadult females, a subadult male, and two cubs completed the count. The bear density for the west side was one bear per 13 square miles of study area or one bear per 8.7 square miles of forested habitat below timberline.

A comparison of the east vs. the west side subpopulations showed no mortality of adult females on either side of the park during the study, but the male bear population on the east side of the park showed exploitation and considerable turnover. No adult resident males were captured here, only subadults. Males did not live long enough to become mature.

The study provided insight into the causes of this male mortality. Three of the 5 subadults eventually captured here were killed, 2 by legal hunting outside the park and 1 by unknown causes. In addition a fourth mysteriously disappeared from the population. The subadult males, apparently because of their less wary nature and needs for more space, wandered in and out of the park, subjecting them to human predation outside.

Boundary Effect

The project researchers noted a "boundary effect" of human use and development outside the park in relation to bear land use inside the park. Much of the area outside and adjacent to the eastern park boundary was occupied by the town of Estes Park and mountained subdivisions. Bears could not occupy these areas. The females inside the park on the east side survived in home ranges far within the park boundaries. On the east side we found areas within the park that we called vacant bear habitat. These were areas extending inside the park for 1 to 2 miles where bear habitat was suitable but rarely used because of high human use outside the park.

The land tenure system and population structure of bears on the west side of the park was considerably different from the east. Here much of the area outside and adjacent to the park was USFS land. Mature males were found on this side in addition to subadults. There was no mortality of these bears while they were being radiotelemetered. Most of them had large home ranges that were partly in the park but extended for many miles to the west outside the park. Several females had home ranges straddling the boundary here, and they would move in and out of the park freely. One area outside and adjacent to the western park boundary did not contain park bear home ranges. This was the township of Grand Lake; park bears avoided this area.

Radiotelemetry showed the adult females had exclusive home ranges averaging about 20 square miles. Home ranges of the large males were not obtained; however 2 smaller males had ranges from 16 to 26 square miles in size.

Secretive Behavior

We found black bears at ROMO were unique in behavior compared to those in other parks. In many national parks black bears are highly visible and frequent human use areas. In contrast, the ROMO bears secretive and avoided human use areas. The park has about 600,000 visitor days of hiking use on the trails, but bears and bear sign are seldom observed. Intensive radiotracking of two east side female bears, which had home ranges in the areas of heaviest human use, indicated they were almost never found in human use areas. On average they were radiolocated about 1 km from trails, 2 km from trailheads, 2 km from dirt roads, 1 1/2 km from paved roads, 2 km from picnic areas, 3 km from human residences, 5 1/2 km from the major campgrounds, and stayed about 6 km from the park boundary (McCutchen, 1990). As we interpreted it, the bears partitioned the space, with humans using the network of roads and trails and the bears using the interstitial areas.

Because bears and other large carnivores reproduce so slowly, it requires several years of study to obtain some idea of their population dynamics. The research on the bears in the park was extended into 1990, 1991 and 1992 to gain this information.

Low Reproductive Rates

We found that reproductive rate and success among black bears at ROMO were among the lowest on record for any study of black bears in North America. Females in the park did not successfully reproduce and bear their first litters until they were about 7 years old. Generally black bears in the western U.S. have cubs at about 4 to 5 years of age (Beck, 1991), and the bears in the eastern U.S. reproduce at about 3 years (Alt, 1989). Litter size at ROMO varied from one to 3 cubs but overall was quite low, averaging 1.7 as compared to Beck's (1991)

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Summer capture crew members Steve King (left) and Jeff Gould measure immobilized black bear snared in Rocky Mountain NP.

findings in southern Colorado of 2.0. and Alt's (1989) 3.0 for Pennsylvania. To put this in perspective, assuming a 2 year litter interval, a 10 year old female black bear in Pennsylvania would have produced 12 cubs in her lifetime whereas a 10 year old female at Rocky Mountain National Park would have produced 3 or 4.

The sex ratio of cubs at ROMO was about 1:1 males to females, similar to other studies. Cub survival, e.g. the percent surviving from birth to 1 year of age, however, was extremely low, averaging about 43 percent as compared to 56 percent found by Beck (1991), who considered his cub survival low as compared to other studies. The causes for cub mortality at ROMO need further study. Two sources of cub mortality identified were starvation in the den and cannibalism by other bears.

The black bears at Rocky Mountain NP also were found to be among the smallest on record. Mature females weighed from 80 to 165 pounds as compared to weights of 130 to 235 pounds (Beck, 1991) for female black bears in southern Colorado. Mature males weighed from 140 to 240 pounds as compared to males in the southern Colorado study (Beck, 1991) which weighed from 176 to 350 pounds. Yearlings at ROMO were consistently small. Both females and males averaged about 26 pounds as compared to averages of 48 pounds for females and 50 pounds for males in southern Colorado (Beck). We surmised that one of the causes of yearling mortality was low body weight going into hibernation.

The small body sizes, late maturation and low rates of reproduction of the bears in Rocky Mountain NP appear to be functions of the habitat. Beck (1991) considered the park area marginal for bears and judged that his study area in southern Colorado was above average. In Beck's area, where the bear habitat was somewhat lower in average elevation, the bears had two major feeding economies to draw from; beginning in early summer and into the fall berry crops provided food; in late fall acorns (hard mast) from abundant oak stands were utilized. In this area also there is greater habitat diversity with many patches of vegetation in various seral stages.

At Rocky Mountain NP the growing season in the bear habitat is very short, and the climate is essentially subarctic (subalpine). The extremely high elevations and dry cold result in low productivity of food bearing plants. Further, the bears have only one major feeding economy - berry crops - from mid summer to early fall. There is no oak in the park. One important, but infrequently produced, hard mast crop which the bears did utilize was the tiny seeds from limber pine in late fall. Bear habitat diversity in the park is limited. Much of the park's forest is mature; there is not a good mosaic of various seral or age stands. This is due to the park's vigorous protection from wildfire for the 77 years since its establishment.

Multiple Pressures

The research indicates that low densities and numbers of black bears in Rocky Mountain NP result from a combination of factors. First, along the eastern park boundary the town of Estes Park, subdivisions, summer homes, resorts and other forms of urbanization have usurped and fragmented bear habitat and constricted travel corridors. These areas also act as "population sinks" where emigrating bears come into conflict with man and are removed from the population.

Second, hunting pressure along the eastern boundary appears to have been so great as to nearly eliminate the older male age classes. The Colorado State Division of Wildlife is aware of this hunting pressure and since 1986 has formulated more restrictive regulations for bear hunting in areas surrounding the park.

Third, visitor use on the east side is extremely heavy on roads and trails. Many human use areas are in highly productive bear habitat (riparian areas and aspen stands). Because of their unique human avoidance behavior, the bears do not use this habitat, which reduces the area's carrying capacity for the species.

Fourth, historic fire suppression has degraded the bear habitat causing further reduction of the black bear carrying capacity. The park is developing a fire management plan that will include prescribed burning. Restoring the park's fire regime eventually will create the needed vegetative mosaics and increase herbaceous and shrub primary productivity needed by the bears. Fifth, this high mountain area is marginal habitat for the bears, and their reproductive rate is correspondingly low.

Summary of Results

In summary, this 7 year study of black bears in Rocky Mountain NP reveals that the species is being heavily impacted by humans. The population is very low. The census of the study area on the lower 2/3 of the park indicated a population of 21 bears. Extrapolating for the entire park there is probably a population of about 30 to 35 bears. Recruitment of 2 subadult females to the breeding population set the trend slowly upward. Male age classes on the east side of the park show exploitation, however radiotelemetry revealed no evidence of poaching of bears inside the park.

The bears are of small body size and exhibit late maturation and low rates of reproduction. Their high avoidance behavior to humans explains why park areas of suitable habitat are not being fully utilized. The four factors of impact, coupled with the species very low reproductive capacity, have made this a subpopulation at risk. The population is so small in the park that the loss of 2 or 3 adult females would put it on a downward trend.

Although the habitat is marginal, research indicates that the bear population would be significantly larger (by perhaps as much as an estimated 30 percent) if human impacts were eliminated or mitigated. Periodic monitoring of the black bear population in the park is essential. The species is an indicator of the impacts of human use on the area as well as an indicator of ecosystem (forest) health.

From an ecosystem viewpoint the black bear population at Rocky Mountain NP provides a useful model of what can happen to large carnivores in a preserve when the area is too small to maintain a viable population and begins to suffer from the "island effect," being encroached upon by adverse human land uses.

The information obtained by this research project was incorporated into the bear management section of the park's Natural Resources Management Plan.

McCutcheon is a Research Wildlife Biologist with the NPS Rocky Mountain Region, stationed at the CPSU at Northern AZ State University, Flagstaff.

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Data Base Mapping and Management at Colonial NHP

By Janet L. Johnson, John Fels, Chuck Rafkind, and Hugh Devine

Since its modest beginnings in 1987, GIS use at Colonial has experienced rapid growth in both the range of resource management issues it addresses and the corresponding physical size of its database. Both natural and cultural resource information is being added to the system at an increasing rate, forcing the park to institute a more formal system of organization, management, and output of its GIS data.

In the summer of 1991, the park enlisted the GIS Research Program at North Carolina State University (NCSU) to design a Database Management System (DBMS). The objective was a system design that would facilitate expanded use of Colonial's GIS and provide better management and control of the database. Four major factors were considered: accessibility, usability, reliability, and adaptability.,

The main accessibility concern was that the GIS be available at multiple locations throughout the park. There is little value in data that is not on-hand or accessible when needed. The second factor--usability--requires that the database be usable by personnel with limited GIS training and experience. A GIS DBMS that is too difficult will frustrate first-time or casual users and will tend to discourage all but the most experienced database users. The third factor--reliability--is contingent on at least three criteria: (1) the database must be secure from unauthorized access; (2) it must be properly stored so that a catastrophic event such as fire or hurricane does not destroy it; and (3) it must be updated, documented, and distributed to users in a timely manner. Adaptability--the final critical design factor--is about insuring that the DBMS design be flexible enough to allow for reconfiguration as GIS experience grows. It is unlikely that any one design will serve indefinitely as GIS use continues to expand and change.

DBMS Design

The GIS program at Colonial is managed by the park's Natural Resource Management Specialist and use of the system is distributed among four work areas. Two of these are within the park's Natural Resource Management and Protection division; the other two are located within the Interpretaive and Cultural Resource Management division. Expansion to the Maintenance division is planned. The computers are DOS systems and are not networked. The park uses the ATLAS*GIS software program and exchanges data routinely with local and state governmental users of ARC/INFO. Currently, there are 148 layers of themes in the park GIS database.

The study developed and evaluated two basic DBMS designs: the first would combine all the GIS layers into one large file, eliminating the need for a user to keep track of multiple subdirectories or files of data within the system; the second would divide the database into a number of files that would reduce the database size for an application and facilitate development of new layers and map products by linking multiple themes *logically*, not physically.

The first file design maximizes user accessibility, as any part of the GIS database could be retrieved without the difficulty of invoking separate files or subdirectories. Reliability is achieved in that the database is backed up, edited, and restored in its entirety. This means new versions of the database could be installed with very few commands, and back-ups could easily be performed and catalogued. Flexibility is a mixed result with this design, as the addition of new layers is simple, but the manipulation and cataloging of the numerous layers is complex. For example, just remembering the name of the layer for utility rights-of-way, let alone what is in it, could be a problem. This design's major drawback is usability. Stepping through 148 layers, turning them on or off for a mapping application, is a tedious process; further, the time and commands required to effect a mapping change would be significant due to the large size of the database.

The second DBMS design, one that employs multiple files as a way of grouping themes into logical categories, was chosen for implementation. This design divided the 148 themes into 10 files. The subdivided design was significantly easier to operate, since development of a map, application, or analysis involves manipulation of very few layers. Although his was offset somewhat by having to access several files, the net number of commands and time requirements for map production was greatly reduced. Accessibility and reliability are slightly compromised unless every file is maintained in every computer. Some infrequently used files may be temporarily unavailable from a given work area, but our experience has not shown this to be a major problem.

Finally, adaptability is enhanced, as the addition or reconfiguration of the master files involves the use of a small subset of the total database, and tracking where information is stored is considerably simpler.

Ongoing Work and Recommendations

The design of the DBMS has definite implications for both the symbolization (i.e. map representation) of map analysis products with the GIS and the operational procedures for managing the system. At Colonial, the development of the DBMS has proceeded concurrently with the construction of guidelines and procedures for these other activities. The results have been formalized into the park's *GIS Database Management System and Map Presentation and Feature Taxonomy* standard operation procedure.1

The DBMS design and subsequent implementation has proven useful at Colonial. In addition to addressing the obvious need for data organization and control, it has produced the unexpected benefit of clarifying the role of GIS within the park and indicating the extent to which GIS can be utilized.

For the near future, the park is working to refine DBMS and Map Preparation and Feature Taxonomy operating procedures. During FY 93, a more complete data dictionary, detailed numerical classification system, and expanded input of attribute data will be undertaken. Also, as the ATLAS*GIS program is released in a Windows version, the park will explore linking it with digital photos from the resource management files. The park plans to embark eventually on digital orthophotoquad research with the USGS.

This design works well for Colonial, but we recognize it may not suit the needs of other parks. It is hoped however that this study will facilitate other GIS DBMS designs, and for those who elect this path, Colonial's construction processes can provide guidance.

[1] The GIS SOP is available from the park by sending a DOS formatted floppy diskette and self-addressed stamped diskette mailer to Colonial NHP, Natural Resource Mgt. Spec., PO Box 210, Yorktown, VA 23690.

Johnson is a research associate and Fels is a Ph.d candidate with NCSU's GIS Research Program; Rafkind is GIS Coordinate/Natural Resource Management Specialist at Colonial; Devine is Director of the NCSU GIS Research Program.

FILE NAME	CONTENTS OF GEOGRAPHIC FILE	DESCRIPTION OF GEOGRAPHIC FILE LAYERS	COLOR
HYDRO	1 HYDROGRAPHY	shorelines of rivers, ponds, lakes, rivers, streams, drainages, springs, floodplains, watersheds	blue
VEG	2 VEGETATION	forest, fields, wetlands	green, aqua, brown, cyan, yellow, sky blue
ACCESS	3 ACCESS	primary, local, public and park, administrative, fire roads; trails	black, red, orange
INFRAST	4 INFRASTRUCTURE	utilities (park, public-row's), structures - buildings, bridges, fences, man-made drainage, signs	black, red, blue, green orange, brown, yellow
BOUNDARY	5 BOUNDARIES	park, local, county, state, reserved row's, park scenic easements and fee simple	black
CULTURAL	6 CULTURAL	pre-contact, 17th, 18th, 19th, 20th century, archaeological excavation sites - sites, buildings, other structures, earthworks, historic roads	purple, violet, red, orange, yellow, brown
ADJACENT	7 ADJACENT LAND USE	residential, commercial/industrial, military, public lands, agriculture	orange, red, violet, yellow,green
ENVIRON	8 ENVIRONMENTAL	soils, topography, wildlife sightings, vegetation monitoring, erosion problems, RTE, critical habitats, fire NFFL, fire NFDRS	brown, red,
REG	9 REGULATORY	Ches. Bay RPA/RMA, floodplains, tax parcels, zoning, land status within park	violet, black, orange
GEOD	10 GEODETIC CONTROL	kilometer markers, UTM grid, Long/Lat grid, geodetic controls points	violet, yellow

Colonial GIS database is divided into 10 master files. These files represent groups of layers combined by common features.

Impact Monitoring and Restoration in Mount Rainier NP

By Regina M. Rochefort and Stephen T. Gibbons

Each year about 2 million people come to Mount Rainier NP. Day hiking and camping are among the most popular activities; subalpine and alpine meadows are the most frequently visited destinations (Johnson et al, 1991). Almost 3/4 of all visitors go to Paradise, a beautiful subalpine meadow located on the main park road.

The Paradise area has been a popular attraction since 1915, when the road first was opened to automobiles (Martinson, 1966). Other subalpine areas, such as Spray Park, have been heavily used since the 1890s, when hundreds of tourists were guided in over mining roads (Martinson, 1966). This sustained level of heavy use has resulted in numerous bareground and/or severely eroded areas. To deal with this problem, Mount Rainier has developed a comprehensive system of impact monitoring and restoration. The program was developed first for the Paradise Meadows and now has been extended to the entire park.

Impact sites are stabilized with silt bars, ready for filling and revegetation.

Restoration crew is shown here installing stabilization bars or silt dams; the area in the foreground has been filled with gravel and will next be filled with soil.

Paradise Restoration

The Paradise meadows encompass approximately 389 ha (960 acres) and extend from 1,646 to 2,256 m (5,400' to 7,400') in elevation. Most of the meadow is within the subalpine parkland zone (Franklin and Dyrness, 1984), although a small portion is above treeline and is dominated by alpine vegetation. Park policy is to discourage off-trail hiking due to the fragility of the subalpine vegetation, but off-trail travel still persists, causing new impacts and perpetuating existing bare-ground impacts.

In 1986 the park began a large scale program to repair human-caused impacts in the meadow. The first step was to form an interdivisional committee to write a plan for protection and restoration of the meadow (Rochefort, 1989). Members of the committee were Doug Buehler (Interpretation), Mike Carneyu (Trails), Steve Gibbons, Rick Kirschner and Garry Olson (Ranger Division, Bob Elmore (Landscape Architect), and Regina Rochefort (Botanist, chairperson).

The plan was developed over a 3 year period; steps included field surveys of impacts, sociologic surveys regarding noncompliance and optimal control methods (Johnson and Swearingen, 1988), and development of a method to rate and rank impacts for restoration.

Impacts Documented

Field surveys in 1986 and 1987 documented 913 human-caused bareground impacts in the meadow. Approximately 89 percent were informal "social" trails. The remaining impacts (11%) were large bareground or trampled areas used as rest and/or view points. Impact dimensions are variable: lengths range from 0.5 to 1,500 m, widths from 0.1 to 25.6 m, and depths from 0.01 to 0.95 m.

The sociologic study, conducted by Darryll Johnson and Thomas Swearinger (U/WA CPSU), tested 7 sign texts, 2 types of barriers, and the influence of a uniformed NPS employee on off-trail hiking. The authors also developed a profile of non-compliers.

The study showed that the standard sign text in use at that time (Meadow Repairs, No Hiking) was the least effective text tested. Both barriers were effective, but the yellow polypropylene rope was more effective than split rail fencing, perhaps because many visitors came from urban areas and equated ropes to area closures. The sociological study also indicated that the mere presence of a uniformed NPS employee reduced non-compliance to a negligible level, showing that visitors did indeed know they were expected to walk on maintained trails.

The study results led to revised regulatory sign texts within the meadow, additional interpretive signs in the meadow and visitor center exhibits, and increased meadow roves by Interpretive Rangers.

Restoration Rating Criteria

Restoration rating criteria were developed by the Paradise Plan Committee, Dr. William Rippe (OR/State/U), and Susan Fritzke (now at Yosemite NP), to quantify relative damage of each site and the potential for continued damage, and to produce a ranked list of all impacts for restoration. The rating is the product of 2 numeric values: soil erosion potential, and aesthetic or visual quality (Rochefort, 1990).

Seven factors are used to estimate soil erosion potential: vegetation type, soil texture, length of impact, depth of impact, width of impact, slope, and percent bare ground. Three factors are evaluated to determine the visual quality of the impact: distance from a developed trail, visibility, and accessibility. In addition, notations are recorded on a number of qualitative factors: safety hazards; presence of rare, threatened, or endemic species; laws or regula-

Anastasia Island Beach Mouse 'At Home' at Fort Matanzas National Monument

By Philip A. Frank

Fort Matanzas National Monument (FMNM) is a small park on the southern tip of Anastasia Island, a slender 14 km long barrier island on the Atlantic coast of NE Florida. Its featured attraction is a beautifully preserved 16th century fortification built by the Spanish to control access from the south to the town of St. Augustine. Less well known is its status as a prime example of coastal strand--one of Florida's rarest and most imperiled natural communities. The dune communities there are home to a wide variety of wildlife, including several threatened and endangered species, most notable of which is the Anastasia Island beach mouse (AIBM, *Peromyscus polionotus phasma*), a small mammal endemic to the Island.

Beach mice are coastal forms of the more common and widespread oldfield mouse that occurs throughout the southeastern United States. These mice inhabit coastal dunes along the Atlantic coast of Florida and the Gulf coasts of Florida and Alabama. Beach mice are habitat specialists, preferring primary dunes and adjacent coastal strand and scrub. They are entirely nocturnal and pale in coloration, closely matching the light beach sands they inhabit.

Because of beachfront development throughout Florida, the loss of beach mouse habitat has been extensive, and much of the remaining habitat is fragmented, disturbed, and occupied by exotic cats and house mice. As a result, 6 of the 8 subspecies of beach mice are listed as either threatened or endangered, and one subspecies formerly found on the barrier island to the south of Anastasia Island is believed to be extinct (Humphrey and Barbour 1981).

The AIBM was listed as endangered in 1989, and I have been conducting field research stressing basic ecology in order to guide management for the beach mouse. Research has been funded by the Florida Game and Fresh Water Fish Commission's Nongame Program, with additional support from the University of Florida and the Florida Museum of Natural History.

Anastasia Island is developed over most of its length; only 2 parcels of land remain essentially undisturbed. Fortunately, both are publicly owned, and are managed with the needs of the beach mouse in mind. Anastasia State Recreation Area (ASRA), located at the island's northern end, is managed by the Florida Park Service and has approximately 6.5 km of linear dune habitat. FMNM at the southern end is considerably smaller, with about 1 km of linear dune habitat. Because of the protected status of FMNM and ASRA, these locations are critical to the long-term persistence of the AIBM.

The primary method used to study the beach mouse was live trapping--on a series of grids located at FMNM and ASRA, and on transects

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Impact... Mt. Rainier, cont'd from p. 29

tions affecting the site; and potential impacts on aquatic or wildlife resources.

Impacted sites are ranked numerically, but if the impact affects one of the qualitative factors, it can be raised to the top of the prioritized list during annual, interdivisional reviews. All field data are entered into a computer data base (dBase program, which can be run on any IBM compatible computer), developed by Dr. Richard Frenzel. The computer data base calculates numeric rating values of each impact and prints reports of numeric values, qualitative factor notations, and the supplies required for restoration of individual sites (e.g. soil and gravel volumes, numbers of greenhouse plants). The program also contains modules for entering reports on restoration efforts (supplies used, hours spent, costs, materials, etc.) and monitoring results.

Restoration Methods

Restoration of individual impacts involves 6 steps: scarification, stabilization, filling, revegetation, site protection, and monitoring (Rochefort, 1990). Many sites have become compacted and must be scarified to enhance root penetration and water percolation. Impacts deeper than 3 cm require stabilization to impede downhill movement of soil. Wood or rock silt bars are installed as subsurface erosion control structures.

Following stabilization, the site is filled to the grade of the adjacent undisturbed area. Fill material consists of 3 components: rock, gravel, and topsoil. All topsoil is purchased from outside the park but specifications require it to be approximately the same soil texture, pH, and organic matter content as that of native soils. Soil is steam sterilized to prevent importation of exotic seeds.

Once the site has been filled to grade, it is revegetated, using 3 techniques: seeding, transplanting, and natural revegetation. Most sites in Paradise are seeded and planted rather than allowed to revegetate solely by natural means. All seeds are collected as close to the impacted site as possible, to maintain the genetic integrity of the site. Transplants are either salvaged from within the impacted site prior to filing, or grown in the park's greenhouse from seeds or plant stock collected in close proximity to the impacted site (Davis, 1991).

Mount Rainier NP has completed restoration of 35 social trails; an additional 24 sites have been partially completed. Restoration over the past 6 years has cost $810,000 and required 24,404 workhours. Approximately 30 percent of this cost has been personnel wages; the remainder has been for supplies, materials, and private helicopter use. The work has required 645 m^3 of soil, 260 m^3 of gravel, 137 m^3 of rock, and 29,150 greenhouse and/or salvaged plants.

Park-wide Applications

Impact surveys in Paradise began in 1986 and were completed in 1987. In the winter of 1987, it was decided to expand the impact monitoring program to Spray Park. Paradise methods were revised and further tested in Spray Park. These methods now are used systematically to survey management zones within the park's Wilderness as funding permits. Impact monitoring is carried out on alpine areas by Rochefort; subalpine and forested areas are monitored by Natural Resource Specialist Barbara Samora. Currently 11 of the park's 22 alpine zones and 5 of the 33 subalpine zones have been inventoried (1,591 total impacts). Impact data are used both to direct restoration efforts and to develop Limits for Acceptable Change (LAC) standards within the park's Wilderness. Currently LAC standards have been revised for 8 alpine zones, 1 alpine camp, and 2 subalpine zones based on impact surveys (e.g. revised limits on numbers of camping parties/night).

All impacts are entered into 1 data base and restoration efforts are directed at the highest priority impacts. Restoration plans are developed by a variety of personnel, depending on the size of the impact. Small projects are the responsibility of the area ranger; larger projects have been planned by the Botanist or an interdivisional committee.

Pam Griffin supervises restoration crews that work on large projects such as those now underway in Paradise, Spray Park, and Sunrise. Implementation of large projects also rely on substantial support from trail crew and roads personnel. Protection and monitoring of restored areas is a shared responsibility of Ranger, Interpretive, and the Planning and Design and Natural Resource divisions.

Rochefort, Botanist at Mount Rainier NP, is pursuing her Ph.D. at U/WA; Gibbons is a Natural Resource Specialist in the NPS Pacific Northwest Regional Office as well as National Natural Landmarks Coordinator.

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located over the entire length of the island. The grids were trapped quarterly from January 1989 to January 1991, and the transects were trapped during the summers of 1989 and 1990. Information from the grids was used primarily to estimate beach mouse density and predator (feral cats) abundance, while the transects provided data on island-wide distribution. The main study sites were FMNM and ASRA, although beach mice also were studied in a variety of conditions including severely degraded habitats adjacent to development.

Beach mice are distributed over nearly the entire island, with the exception of an area where the natural vegetation has been replaced with concrete reinforcement to deter erosion. The mice occupy sites with conditions ranging from relatively pristine (ASRA and FMNM) to severely degraded. Their population levels were found to be extremely variable, both in space and time. In high quality habitat, densities may range from 2 mice/ha to 90 mice/ha, with an average density of around 30 mice/ha. Over the 2 years of trapping, no seasonal pattern in abundance was obvious, although there was a tendency for populations to be at high levels in winter. Densities in the disturbed habitat adjacent to development were generally much less, compared to ASRA and FMNM. Habitat availability, habitat quality, and the presence of large numbers of domestic cats may have caused this difference.

Although separated only by a short distance and appearing superficially similar, population dynamics at FMNM and ASRA were quite different, suggesting different ecological factors are operating at these locations. One striking difference was the presence of large numbers of feral cats at ASRA, whereas cats were quite rare at FMNM. Data collected at ASRA over the 2 year study suggest a negative correlation between cat abundance and beach mouse density (Fig. 1). That cats are capable of depleting wildlife populations is common wisdom among field biologists (Churcher and Lawton 1989), but field documentation is usually lacking.

Recommendations for management of the AIBM include eliminating cats, both feral and free-ranging domestic types, from beach mouse habitat, preventing habitat damage from foot and vehicular traffic, educating the public on the plight of the beach mouse, and establishing a second population separate from Anastasia Island. This second population establishment is a high priority for the recovery of the AIBM, as it will reduce the potential for extinction caused by a catastrophic hurricane such as Hugo, which devastated the Carolina coast in 1989.

I am currently working on a reintroduction project in cooperation with the Florida Park Service, the National Park Service, and the U.S. Fish and Wildlife Service. The reintroduction would be to Guana River State Park, a prime site within the historic range of the subspecies located on a barrier island immediately north of Anastasia Island. Using methods like those used in a similar project (Holler et al. 1989), approximately 20 pairs of mice will be taken from several locations on Anastasia Island, including FMNM, so as to include the range of genetic variability into the founder population.

The reintroduction began in the fall of 1992, a time of maximum food availability and population densities, and the population will be monitored for 1 year, initially. Success of the reintroduction effort will be measured by growth and expansion of the population. If successful, this effort will significantly enhance the survival probability for this unique mammal.

I would like to acknowledge Wallace Hibbard, Brian Peters, and Rick Gushew of the NPS (FMNM) and Doug Carter, Paul Crawford, and Robin Huck of the Florida Park Service (ASRA), who provided valuable assistance, as well as Dr. Stephen Humphrey of U/FL who initiated this research and gave ongoing advice and assistance. Rebecca Henson was invaluable in the field.

Frank is a Ph.D. candidate at U/FL, Dept. of Wildlife and Range Services.

The Anastasia Island Beach Mouse

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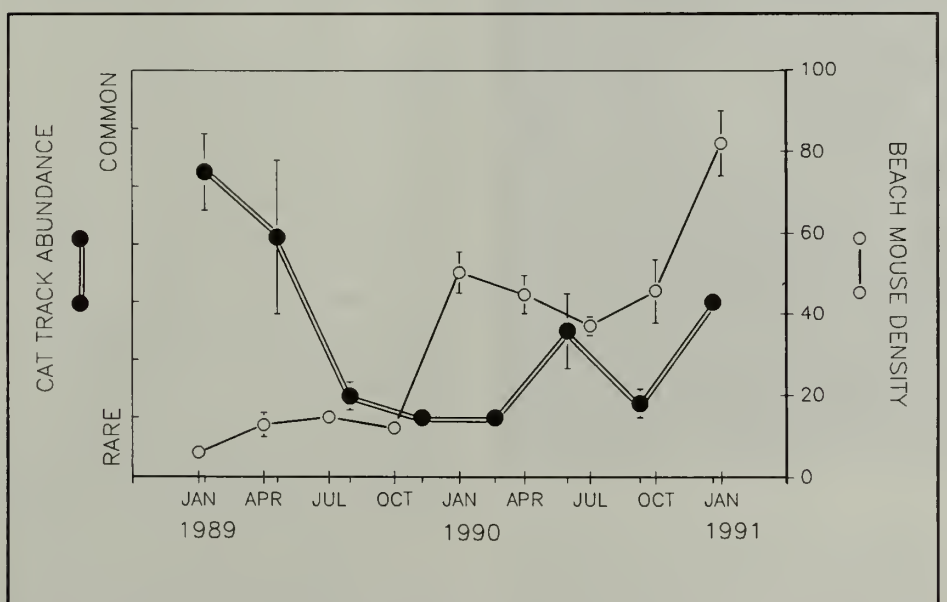

Figure 1. Beach mouse density (individuals/ha) at Anastasia Island State Recreation Area, St. Johns County, FL, compared to house cat abundance as determined through track counts indices. Cat numbers were reduced by park staff beginning in fall, 1989, followed by a significant increase in the beach mouse population.

IN THE NEXT ISSUE. . .

- Carol L. McIntyre's **Notes from Abroad**;
- **"Predation of Yellowstone Elk Calves"** by Frank Singer;
- **"Subalpine Meadows: Promising Indicator of Global Climate Change"** by Andrea Woodward and June Rugh;
- **"Biological Implications of Trophy Hunting of Dall Sheep in Alaska NPs and Preserves"** by Frank Singer;
- **"Geologic Mapping Program at Great Basin NP"** by Janet L. Brown;
- **"Window to the Past"** by Carol McNulty-Huffman;

plus some holdovers previously promised and some newly-promised articles on native plant protection, the Grand Canyon willow fly catcher, and an evaluation of Mammoth Cave NP's groundwater basin.

USGS and NPS: Science Partners...
cont'd from p. 1

The right answer, of course, is both. Both the wonder of the beauty and the wonder of the science combined to make the first parks possible. And that natural partnership has lasted and must continue. I cannot imagine doing earth science without our national parks. I cannot imagine national parks thriving without good science.

As USGS Director, I can think of no better way to celebrate the accomplishments of the first 75 years of the National Park Service than to re-dedicate our partnership. As part of that re-dedication, Doyle Frederick, Associate Director of the USGS, and I had the pleasure earlier this year of sitting down with NPS Director Jim Ridenour and NPS Associate Director for Research Gene Hester to discuss ways of renewing and expanding the various understandings that formally bind our 2 agencies.

In follow-up sessions between our senior staffs, it was evident that our work together really needs no formal bind. I think we all were extremely pleased with reports of many joint projects underway and being discussed. It also is evident that our partnership continues to include the original elements of scientific description, interpretation, and discovery. But more and more our modern partnership is and must be expanding into 2 key areas:

* We must work harder to help the NPS interpret and explain the earth, water, and geographic science of the parks. We scientists are good at telling one another about the magnificent science revealed in each park. We must learn to share that scientific story with the park visitor and thus help to enhance the visitor experience. In a way, we've been too selfish with our science. It's time to share better the wonders of park science by providing more assistance where needed to the NPS park interpretation program.

* Perhaps even more important, our geologists, hydrologists, and cartographers need to work harder to share their science with park management and to provide information needed by management to make the best-informed decisions about protection and enjoyment of the parks. For our part, that means focusing on the information needed by park management and meeting the deadlines for supplying that information. Not all science and not all scientists can meet these conditions, but we are moving in that direction.

USGS geologists, hydrologists, and cartographers are increasingly being asked to help park managers develop the data and knowledge that will repair or head off overuse and misuse of parks by the swelling number of visitors. Increasingly, the earth scientist is asked to provide the long-term perspective on the environmental conditions of the past and likely conditions and changes of the future.

The following articles provide a taste of the range of joint scientific efforts underway: modeling climate change, water temperature and biological productivity in Yellowstone Lake; sediment transport and beach erosion in Grand Canyon; natural resources and natural and manmade hazards in and around park borders; coastal geology and pollution; fossils on the public lands; and atmospheric emissions and biochemistry.

But these articles provide only a taste of the exciting science that USGS and NPS are conducting together in the national parks...only a taste of the expanding partnership between the managers and scientists of NPS and USGS. Looking to the future, I am particularly pleased that 3 of our newest major program initiatives--National Water Quality Assessment, National Geologic Mapping, and Accelerated Production of Digital Base Cartographic Data--are finding immediate appeal and application to NPS.

Like all good partners, we sometimes disagree on methods and answers. In fact, it is often hard for our own scientists to agree on a single answer. But that is the nature of science--to probe and challenge from different perspectives. As a bureau, we are working harder to develop a consensus response to tough questions in time to help park management do its job and make the necessary tough management decisions.

Few government agencies have accomplished as much in 75 years as the National Park Service. We at the USGS congratulate you. And we accept the challenge to work with you to help make the next 75 years equally productive. Our natural partnership is older than either of us. May it continue to prosper.

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PARK SCIENCE
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Window to the Past: Providing a Framework for theFuture

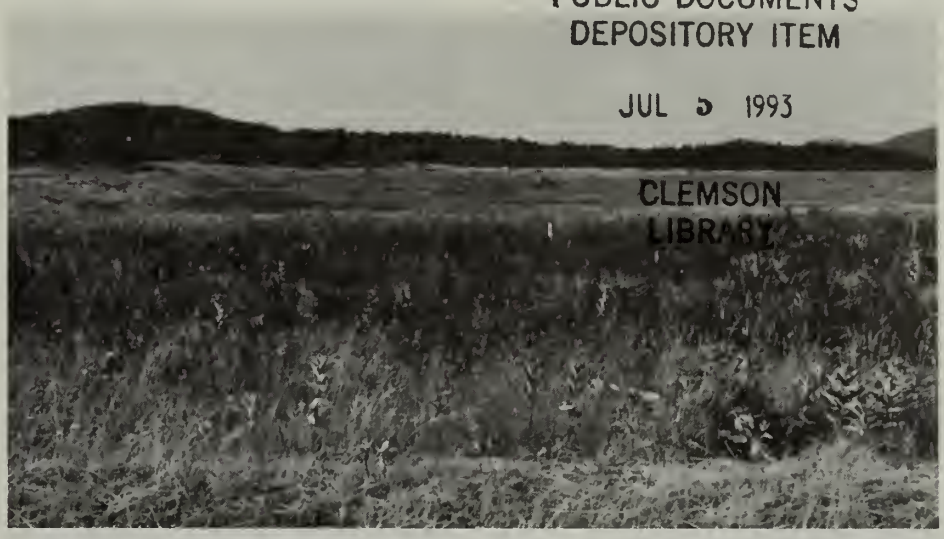
By Carol McNulty-Huffman

Historians are fond of saying that those who forget the past are doomed to repeat it. Such thinking can be valuable for park natural resource managers as well. Taking the time to look at where you have been and what has happened in your park in the past can provide a valuable framework for determining future direction. Often, however, with daily activities demanding your attention, it is difficult to find the time for reflection and research.

In choosing a topic for my master's thesis, I looked for something the park staff would find useful but probably would not have time to do on their own. Dave Haskell, Chief of Natural Resources and Science at Shenandoah NP (SNP), expressed a desire for a comprehensive record on the evolution of resource monitoring activities in the park. I jumped at the opportunity to dig through park files, old research reports, journal articles, and anything else I could find that might prove useful. With the help of John Karish, Mid-Atlantic Regional Chief Scientist, the park staff and I developed this project.

My thesis objective was to document monitoring activity between 1978 and 1988 in 5 areas of the natural resource management program at SNP--air quality, fisheries, integrated pest management, vegetation, and wildlife. I spent 2 years reviewing and synthesizing information, and completed a thesis that the park staff has found useful.

A separate thesis chapter addresses each of the 5 subject areas by (1) presenting a synopsis of research efforts, (2) identifying management objectives, (3) reviewing monitoring programs and presenting a chart of the results or the parameters monitored, and (4) discussing the relationship between monitoring data and management concerns. Following are the highlights of my research.



Big Meadow, an ecologically diverse open area at Shenandoah NP, is both a cultural and a natural resource. *(Photo by Dan McNulty-Huffman)*

Using a flame thrower to selectively kill black locust trees was one of the techniques used for meadow management at Shenandoah HP in August 1983. *(Photo by Dan McNulty-Huffman)*

Research Highlight

SNP, a crown of forested peaks and hollows, lies along the crest of the Blue Ridge Mountains in Virginia. The blue haze for which these mountains were named occurs naturally; it is a combination of dust particles, water vapor, and organic compounds given off by the vegetation, and it is deepening as air pollution increases in the eastern United States.

Air pollution is recognized as one of the most serious threats to the natural resources of SNP. The park is designated a Class I airshed, with special attention to protecting visibility values; thus it has maximum protection under the Clean Air Act from future air quality degradation.

Continued on page 3

PARK SCIENCE

NATIONAL PARK SERVICE

SPRING 1993

A report to park managers of recent and on-going research in parks with emphasis on its implications for planning and management.

ARTICLES

DEPARTMENTS

Editorial

By F. Eugene Hester
Associate Director, Natural Resources

Recently Secretary Babbitt has identified the need for a national focal point for biological information -- a National Biological Survey -- perhaps similar to the U.S. Geological Survey for physical resources and the National Oceanographic and Atmospheric Administration for weather information.

The concept involves the collection, analysis, and dissemination of biological information by a research organization without management responsibilities to maintain objective, credible information not driven by an individual bureau's management decisions.

Biological inventories and research are located in nearly every bureau in government. By consolidating resources to provide a more coordinated and systematic approach to understanding the status and trends of the nation's biological resources, we should be able to anticipate such things as threatened ecosystems. Increasingly there is a recognition that ecological problems cannot be resolved on a single issue or a single species basis, but must be addressed on an ecosystem basis. Early recognition of ecosystem problems should enable agencies to identify more options for resolution than when the problems are identified by such things as petitions to list endangered species at the eleventh hour.

Implementation of this concept within the Interior Department requires many important decisions as to which present financial and manpower resources could be consolidated into this new National Biological Survey organization. This requires an analysis of which resources are essential to bureau missions and local day-to-day management decisions, and which could appropriately be devoted to the new organization to address the broader ecosystem and national needs. Developing standardized approaches to data collection and data management is an essential part of this new concept.

Options for developing this new concept have been formulated. The National Park Service has much to offer and much to gain from this initiative.

With this issue, *Park Science* is going to a slightly larger typeface and a few additional pages. Complaints about the eye-watering print size were well founded, but the amount of "good stuff" coming in from the field simply could not be accommodated in larger type so long as we were bound by a 24-page format.

The compromise of 32 pages of "10-point on 11" type, gives the bulletin the equivalent of about 4 1/2 more pages of the former "9-point on 10" copy. The additional information contained in each issue will take slightly longer to read in its entirety, but the larger type will make reading go faster. One reader recently complained, "The headlines intrigue me, but I can't squint enough to read the articles." The current issue is our attempt to bring the entire contents into easy focus, cover a variety of information from across the Park System, and still keep "reading time" to a minimum.

We continue to urge authors to stay within the outer limits of available space–which is 6 double spaced pages. And we still require that all manuscripts be run by the Regional Chief Scientist and any Superintendent whose park is the subject of the article.

Also, we welcome photographs. Since *Park Science* is a black and white, offset publication, what we need are photos (**not negatives**) that contain enough contrast to "pick up" in black and white. A good way to ascertain whether your color photos will be acceptable is to run them through a photo copier. If they come out looking good in black and white, they'll do. – *Editor*

Air quality research in the park has been extensive; scientific projects have ranged from acid rain research to studies about pollution effects on vegetation. Ozone damage has been found on several plant species, with widespread damage on milkweed. High levels of sulfur were found in lichens.

In 1983 the park staff began a program to monitor ozone and sulfur dioxide levels. Air quality monitoring has indicated that levels of ozone and sulfur dioxide in the park between 1983 and 1988 were just barely acceptable according to standards established by the EPA. For 2 days in 1988 ozone levels exceeded the standards that were established to protect public health.

Visibility Cut in Half

Acid deposition monitoring has showed that precipitation in the park is more than 10 times as acidic as natural precipitation. Visibility monitoring has determined that SNP visibility is among the worst reported at any of the NPS visibility monitoring sites. Comparison with historical records indicates that visibility in the area has decreased more than 50 percent since 1948.

As early as 1936, work focused on the study and management of native brook trout populations so that these fish could be harvested by recreational anglers without negative population impacts. Much of the early fisheries work was accomplished by USFWS and the state of Virginia. The NPS expanded its involvement in fisheries management in 1981 and began a comprehensive monitoring program. In addition to providing opportunities for the public to fish, the fisheries management plan adopted in 1987 aims at preserving native brook trout as an essential element of the aquatic ecosystem.

The essence of this philosophy of management is demonstrated by the new fishing regulations developed for the park. Under the old regulations, all waters in the park were open to trout fishing unless specifically closed. Under the new regulations, all streams in the park are closed to fishing except those specifically designated as open. Unless the brook trout population in a stream is consistently adequate to sustain harvest, the stream will be closed to fishing. These regulations are based on the concept that brook trout have value in the ecosystem beyond their contribution to angler harvest.

Gypsy Moth Management History

The third monitoring program I reviewed in my thesis was integrated pest management which, at SNP is predominantly gypsy moth management. The earliest record I could find of gypsy moths in the park described the capture of a male moth in 1969. It was not until 1984 that gypsy moth infestations became a regular occurrence and the park staff began a comprehensive monitoring and management program. The heaviest defoliation documented in my research was in 1988 and encompassed 16,000 acres (8% of the park). By 1990 defoliation had reached 40,000 acres. Repeated use of insecticides for gypsy moth control is considered only in developed areas that represent about 4 percent of the park land.

Vegetation management has been extensive and includes I&M and management of meadows, vistas, backcountry, and fire. Botanical work at SNP began in the early 1900s, before creation of the park. Much of this early work involved collecting plants and documenting the park's flora.

Big Meadow, an ecologically diverse open area in the center of the park, has attracted the interest of scientists and park staff alike. A fascinating evolution of thought about the meadow, as well as the evolution of management actions taken to protect the meadow, can be traced. Early park management practices to keep the meadow open and similar to the way it appeared in historic times involved mowing the area every fall. Between 1935 and 1969, the meadow went through successional changes that turned the area from a meadow where grasses, sedges, and a few forbs were dominant, to an area that contained about 12 different plant communities, including extensive black locust thickets.

Meadow Mosaic Achieved

Because mowing seemed to encourage the sprouting of black locust trees, park staff investigated other management techniques such as repeat mowing, fire, cutting of individual trees, and treatment of stumps with an herbicide. By 1988, a combination of these methods produced a meadow that appeared to be stabilizing into a mosaic of grass, herbaceous, and shrub communities. Currently, annual maintenance of the meadow involves cutting black locust stems by hand and treating the stumps with an herbicide.

Wildlife management at SNP has focused on bears and deer. Extensive research has been conducted on both of these species. Park staff is working to develop a comprehensive monitoring and management program for deer.

An annual black bear population survey was begun in 1983 and indicates that bear population levels through 1988 were relatively stable. The evolution of bear management in the park, from the time of numerous bear/human conflicts to a time when it is uncommon to see a bear in the park, reflects an emphasis on controlling visitor activities rather than taking action against offending bears.

To Sum It Up...

Taking time to review the monitoring program at SNP was a valuable learning experience for me, and provided the park staff with a useful document. For parks that have not yet taken the time to synthesize and document past resource management activities, Dave Haskell, John Karish, and I highly recommend it. The process provides insights for new directions, reminds you not to repeat past mistakes, and helps reinforce the things you're doing right.

Maybe you can even find a naive grad student like me to do most of the work for you.

McNulty-Huffman is a Natural Resource Specialist at the NPS Denver Service Center. Copies of her thesis, A Review of Natural Resource Monitoring at Shenandoah NP between 1978 and 1988, *may be had from the author at NPS, DSC-TEA, PO Box 25287, Denver, CO 80225-0287; 303-969-2462.*

In the next issue...

- **"Insularity Problems in Rocky Mountain Bighorns"** by Francis J. Singer
- **"Wildland Fire Management at Carlsbad Caverns NP"** by Tim Stubbs
- **"USGS Provides Baselines for Two Alaska Parks"** by J.G. Crock, R.C. Severson, and L.P. Gough
- **"Interpreting Resource Management on a Self-guiding Trail"** by Dave Clark, Craters of the Moon National Monument
- **"Effects of Fire on Cultural Resources in Mesa Verde NP"** by William H. Romme, Lisa Floyd-Hanna, and Melissa Connor
- **"Leadership and Management Course: A Multi-disciplinary Approach to Training at Albright"** by Mark Maciah
- **"Ice Age Floods in Eastern Washington"** by Dan Brown
- **"Evaluation of a Particular Groundwater Basin in Mammoth Caves NP"** by Joe Meiman
- **"High Altitude Mountaineering: Visitor Types and Management Preferences at Denali NP"** by Elan Ewert.

NPS Team Documents Hurricane

Before Hurricane Andrew struck everglades NP, this was a tropical hardwood hammock in Long Pond key near Royal Palm.

By Gary Davis

How did Hurricane Andrew affect the resources of NPS units in South Florida? Immediately after the storm a team of 25 scientists conducted a rapid appraisal of hurricane effects in Biscayne Bay NP, Everglades NP, and Big Cypress National Preserve. They made field observations for one week and gathered information from colleagues who were also active in the field before and after the storm.

Teams were formed for Marine Resources (James Tilmant, team leader), Freshwater Resources (Charles Roman, team leader), Upland Resources (Lloyd Loope, team leader), Archaeology (George Smith, team leader), Air Quality (Brian Mitchell, team leader), and GIS (Donald Myrick, team leader).

Chronic anthropogenic stresses, such as habitat fragmentation, non-native species, altered water resources, and air pollution have affected ecosystem stability in south Florida. Can such stressed ecosystems recover to pre-storm conditions before the next major disturbance? Do storm clean-up activities threaten resources and human health and safety in the parks? These questions needed to be addressed immediately to protect park resources and to develop long-term strategies that assured their perpetuation.

Impacts

Hurricane Andrew was a small, intense hurricane. When it made landfall in southern Florida at 5 a.m. on Aug. 24, 1992, it was a category 4 hurricane, one of the most intense storms ever recorded in Florida. The National Weather Service estimated the maximum sustained wind speed at 150 mph.

The storm hit near the time of high tide. It produced a large but localized storm surge in the coastal portion of southeastern Dade County, 15 miles south of Miami. Storm surge overtopped coastal water control structures and levees. The USGS estimated Hurricane Andrew's maximum storm surge at 16.2 feet. A 105-foot boat was blown from its deep water anchorage and transported inland.

Coastal flooding was minor, but high winds caused extensive damage throughout the 25-mile wide storm path across the state. Rainfall from the storm was low, presumably in response to the storm's rapid forward movement. Rainfall and water levels were above normal throughout most of southern Florida before Hurricane Andrew arrived. Inland flooding was a problem primarily in southeastern Dade County, where saltwater inundated a large portion of farming areas.

The assessment team documented resource conditions immediately after the storm and identified actions needed to avert additional resource damage and recover irreplaceable information. While storm effects on natural resources were dramatic, initial ecosystem responses appeared normal.

Trees sustained severe damage, especially mangroves and tropical hardwoods. Many defoliated trees resprouted within weeks of the storm, and rare plants in hammock and forest understories were relatively unaffected. Coastal wading bird rookeries, eagle nests, and red-cockaded woodpecker cavity trees were damaged, but no major mass mortality of wildlife occurred.

Hurricane winds and water spread non-native plants. Exotic animals escaped from storm damaged facilities and entered the parks. Some freshwater fish populations declined dramatically after the storm. Storm damage to the South Dade water delivery system interrupted normal freshwater flow into Florida Bay. The storm scoured shallow marine communities and altered marine water quality. An artificial reef broke up and moved into Biscayne NP. Sea turtle nesting beaches may have been enhanced by storm overwash, and seagrass beds survived remarkably intact. Windthrown trees and storm-scour exposed previously unknown archeological artifacts on ship wrecks and upland sites. Disposal of urban debris from the hurricane threatens air and water quality in the parks.

Short-term Recommendations

The storm destroyed most of the NPS hydrologic, meteorologic, and air quality monitoring networks in the parks. They need to be replaced and activated to measure the potential effects of post-hurricane cleanup on air and water quality and to evaluate short-term ecological responses.

Historic shipwrecks exposed by the storm need to be surveyed, stabilized, and monitored to enhance site protection. Backcountry patrols need to be increased over normal levels to detect and remove non-native animals before they become established in the parks. Removal techniques for exotic animals may need to be developed and tested in conjunction with other agencies. Short-term ecological storm effects need to be determined, and boat warning signs protecting manatees should be replaced.

Studies to determine the short-term ecological effects of Andrew need to be initiated

Damage at Everglades National Park

After Andrew, the hammered hammock looked like this. *(Photos by James R. Snyder)*

while the first, most dramatic changes are taking place. Historical data need to be compiled and analyzed to provide a basis for designing studies and establishing monitoring plots stratified by hurricane influence. Opportunities to determine spatial variability of storm effects, examine the roles of storm-altered detritus distribution and nutrient cycling, and to evaluate storm effects on fishery recruitment, subtidal sediments, and heavy metals in hardwood hammocks soon will be lost.

Surveys of seedling non-native plants need to be conducted to assess the extent and magnitude of storm-caused spread, and to determine if new control methods should be developed. The status of mangrove forests and rare plant populations will not be apparent until a year after the storm. The environmental monitoring networks need to be hardened to survive future storms in addition to restoring their pre-storm capability. Additional monitoring sites are needed to evaluate storm effects on park resources and link upland effects to estuarine and marine systems. Detection of storm impacts on fish and wildlife will require intensified surveys during reproductive seasons to document reproductive efforts, success, and recruitment.

Significant park staff time will be required to coordinate debris disposal regulated by other agencies to assure protection of park interests. The NPS needs to characterize emissions from debris burning, model air quality and visibility, and monitor air quality, visibility and meteorology to establish actual impacts on park resources.

Removal of artificial reef KEVORKIAN debris from natural reefs needs to be initiated before the debris is incorporated into the sediment and overgrown. Its damage to the natural reef needs to be documented to help develop guidelines for future artificial reef placement. Storm breached plugs on Cape Sable permit accelerated saltwater intrusion into coastal marshes and will continue to widen with tidal flushing if not repaired soon. More permanent solutions to restoring the integrity of these marshes need to be found, such as filling in longer sections near the coast, to prevent this kind of damage and repair costs with each hurricane.

Fire management practices need to be verified following storm-altered fuel loads. Impacts of storm cleanup activities on rare plants and opportunities for interpreting hurricane influences on native communities need to be evaluated. The effects of storm-altered shelter for manatee and crocodile populations on protection activities must be considered before public facilities and access are fully restored.

Long-term Monitoring

Long-term monitoring also is needed, to differentiate natural dynamics driven by hurricanes, fires, and freezes from changes caused by chronic environmental stresses. The monitoring program would be designed to (1) determine current and future health of ecosystems, (2) establish empirical limits of variability, (3) diagnose abnormal conditions early enough to implement effective remedial actions, and (4) identify potential agents of ecological change.

Research Agenda

Finally, experimental research is needed to assess the potential of Hurricane Andrew to alter flows of energy and nutrients in South Florida ecosystems. Potential nutrient releases from storm-related detritus and the effect of changes in landscape heterogeneity on large animals need to be measured over time. A variety of approaches will be necessary to address these questions. Past research and restoration efforts have focused on individual species or habitats, usually within limited spatial or temporal scales.

An integrated understanding of the system's response to anthropogenic and natural perturbations such as Hurricane Andrew would greatly refine ongoing restoration and management activities. Several critical hypotheses concerning the ecosystem's productivity and resilience must be resolved to produce a scientific basis for restoration and management.

In the weeks following completion of the resource assessment, a prioritized list of projects was completed, based on recommendations of the assessment team. That list was presented to Southeast Regional Director Jim Coleman for development of funding priorities by the superintendents at Everglades, Biscayne, and Big Cypress. A multipark meeting took place on Jan. 29, 1993, to establish priorities for the funding available for resource recovery activities. Consensus was reached to proceed immediately on several projects for osprey, cape sable sparrow, hydro station repair/upgrade, and documentation of the Fowey site. Other priorities will be set after the various scopes of services are received.

Davis acted as the NPS team leader in this study; he is a Marine Research Scientist at Channel Islands NP.

Great Basin NP and USGS Cooperate On a Geologic Mapping Program

By Janet L. Brown and Vidal Davila, Jr.

The U.S. Geological Survey (USGS) Geologic Division, through an Interagency Agreement with NPS, is funded to provide basic geologic mapping and geologic thematic data sets to the geographic information System (GIS) newly established at Great Basin NP (GRBA) in Nevada. The GIS is a computer hardware and software system designed to collect, manage, analyze, and display spatially referenced data. The new geologic thematic data sets or themes can then be merged with digital data sets such as hydrography, topography, and transportation, or other themes such as soils or vegetation, to be analyzed for park management purposes. The GIS data sets will be shared between USGS and NPS, as well as local, state, and national data users.

Janet L. Brown (USGS), Vidal Davila, Jr. (NPS-GRBA), and Albert J. Hendricks (NPS-GRBA) developed the research proposal and Interagency Agreement (IA), to provide current large-scale geologic mapping of six quadrangles at 1:24,000 scale. This meets the baseline inventory required by Great Basin NP (Fig. 1).

Interagency Management Plan

The GRBA draft General Management Plan proposes development in several locations in Kious Spring and Lehman Caves 1:24,000 topographic quadrangles, and these proposed developments need geologic evaluation before construction. Brown will act as project manager to coordinate the IA with time frames, budget constraints, and the timely preparation of required maps, reports, and GIS data sets. In addition to having been an interpretive Ranger-Naturalist in two National Parks, Brown has published USGS interpretive geologic maps and USGS bulletins. Her research includes sedimentologic, stratigraphic, and structural analyses of Laramide intermontane basins in the Western Interior.

Academic collaboration for the project is provided by Dr. Elizabeth L. Miller, Associate Professor of Geology at Stanford University, and Dr. Phillip B. Gans, Assistant Professor of Geology, U/CA Santa Barbara. Both Drs. Miller and Gans have done extensive geologic mapping in the Great Basin over many years, have published extensively on geometry and kinematics of normal fault systems in the Basin and Range province, and have made metamorphic and geochronologic studies in the North and South Snake Range. Davila is responsible for managing research in the park; Hendricks, Park Superintendent, integrates research programs with park policy and management needs. Kurt S. Pfaff, Physical Science Technician, acts as archivist to build the park geologic library and provide field assistance.

The project will provide current large-scale geologic mapping of six quadrangles at 1:24,000 scale in two forms:

(1) as published maps, and

(2) as a digitized product compatible with the needs of the GRBA GIS.

These data provide information on suitability and limitations of bedrock and surficial geology for NPS resource uses and activities. The geologic maps will provide data in support of the NPS Global Climate Change Research Plan for GRBA. The USGS Water

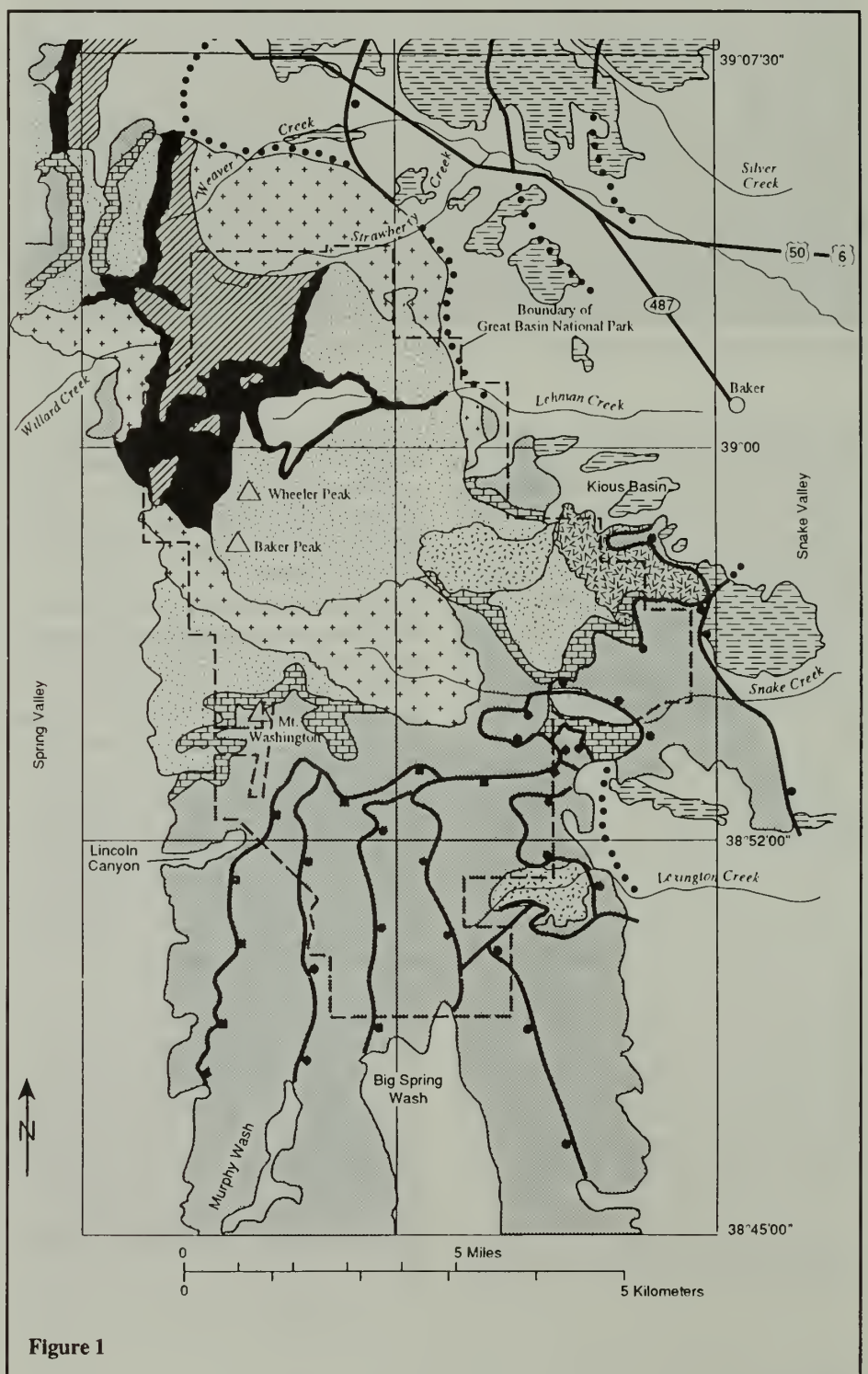
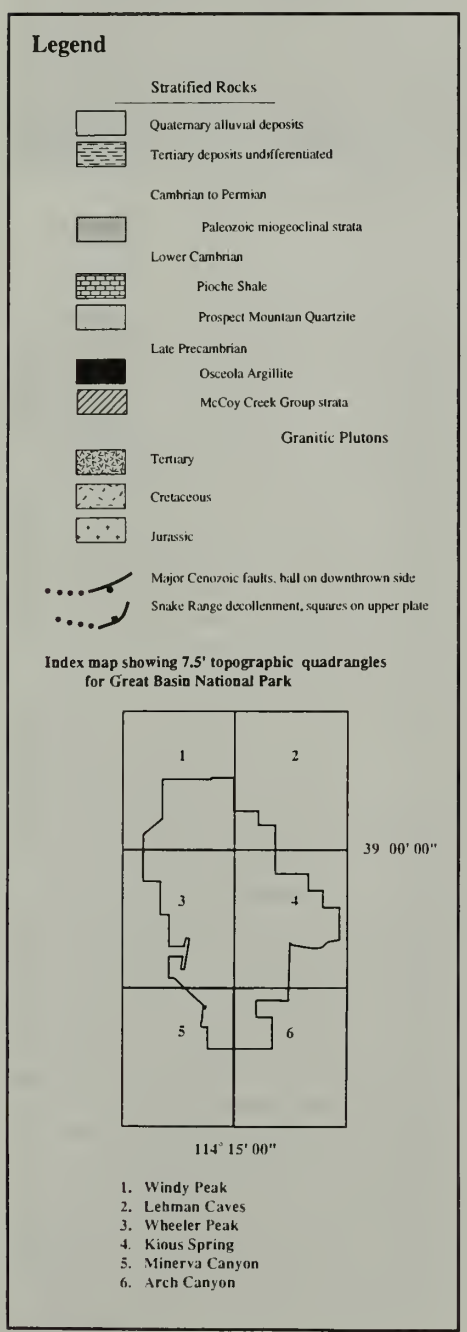


Figure 1

Resources Division and NPS currently are collaborating on research on the water and energy budget for Baker Creek east of the South Snake Range. The geologic mapping and GIS data base support two current USGS Geologic Division Programs: the Evolution of Sedimentary Basins Program in the Eastern Great Basin, NV; and the Basin and Range to Colorado Plateau Transition (BARCO) Program. The maps also will be archived with the national GIS geologic data base in the USGS National Mapping Division Program as well as with the GIS geologic data base being developed for the Nevada Bureau of Mines and Geology in Reno.

Objectives, Methods, and Products

Great Basin NP, a region of great structural complexity, provides important insights into the Cenozoic history of this part of the Basin and Range province. The South Snake Range represents the transition between the unextended Confusion Range structural block to the east and the more highly extended region encompassing the Snake, Schell Creek, and Egan Ranges to the west (Gans and Miller, 1983). It exposes the southern extent of an important low-angle fault system, the Snake Range decollement (Misch and Hazzard, 1962), interpreted by Misch and Hazzard (1962) and by Whitebread (1969) as a thrust fault. The South Snake Range project will provide up-to-date large-scale geologic mapping and data on the movement history of faults in the range, the deformational and intrusive history of metamorphic and igneous rocks, and information on the young uplift history of this impressive mountain (based on studies of Cenozoic conglomerates and apatite fission-track geochronolgy).



The South Snake Range project includes six 1:24,000 topographic quadrangles (Fig. 1), from north to south: Windy Peak, Lehman Caves, Wheeler Peak, Kious Spring, Minerva Canyon, and Arch Canyon. To date, there is no published geologic mapping at 1:24,000 scale of the South Snake Range (see Suggested References).

Field procedures for GRBA will include standard geologic field mapping methods, field checking, and compilation. The field compilation will be assisted by aerial photo interpretation of the geology using the Kern computerized photogrammetric mapping (PG-2). As the geology is mapped and compiled, it will be drafted onto registered stable base greenlines and published as paper copy in USGS Open-File Map and Report format. USGS Open-File Reports serve to make the maps quickly available to the NPS and the geologic community. Additionally, the digitized geologic quadrangles will be available in digitized form as either computer discs or possibly as CD-ROM. A USGS Bulletin on the interpretive geology of the park, prepared in cooperation with NPS, will be written by Brown.

Field work commenced in the summer of 1992. Three geologic quadrangles (Lehman Caves, Windy Peak, and Kious Spring) have been submitted already as USGS Open-File Reports. In the following two years of the project, the remaining three quadrangles (Wheeler Peak, Minerva Canyon, and Arch Canyon) will be mapped and then published as paper copy in USGS Open-File Report format and in digital form. The digitized versions of the six large-scale geologic maps can be combined into a smaller scale version that includes the whole park and is appropriate for other management uses.

As our work unfolds, we anticipate presenting our collaborative results at professional meetings, such as the Geological Society of America Section Meeting in Reno, NV in May 1993. The USGS Bulletin on interpretive geology of the park will be a color publication that will include a geologic map of the park and have contributions from NPS staff as well as academia. The project is slated for completion by Dec. 31, 1994.

Brown is a Research Geologist with the USGS; Davila is Resource Management Specialist at Great Basin NP.

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Pollen Analysis in Historical Landscape Studies: Fort Necessity, Pennsylvania

By G.K. Kelso, J.F. Karish and C. Smith

During his 1754 road building expedition to the forks of the Ohio, Lt. Col. George Washington ordered construction of an earthwork and stockade fortification in an opening in the forest called "Great Meadows." The fort was surrendered to the French and destroyed in July 1754 after a brief siege that now is considered to have been the opening battle of the French and Indian War. The forest surrounding Great Meadows was a critical element in the battle because it provided cover within musket shot of the fort for the attacking French-led Indian force (Washington 1754).

The forest was cleared and converted to pasture between 1856 and 1880 (Torres-Reyes 1970:10). A reconstruction of the 1754 fort (Fig. 1), based largely on Harrington's (1957) archeological data, now occupies the original site, and the Fort Necessity General Management Plan calls for restoration of the forest to its 18th century boundaries by the 300th anniversary of the battle (A.D. 2054).

Figure 1. National Park Service Reconstruction of Fort Necessity based on archeology and documentary sources *(Photo courtesy of Charles Smith, Chief Ranger, Fort Necessity National Battlefield).*

A pollen study of the vegetation history of Great Meadows now is underway, and this paper reports progress in defining the 18th century vegetation communities.

Six soil cores were taken in a transect down the hillside on the western side of the meadow and across the meadow to the edge of the reconstructed fort lawn. Agricultural development at the site is clearly recorded in the pollen spectra of all six cores. Oak pollen frequencies (primordial forest) are highest at the bottom, and grass pollen (the developed pasture) counts are highest at the top of all six Great Meadows cores. Weed pollen, of one kind or another (the clearance period), is most prominent in the center of the cores. This tree-weed-grass pollen domination sequence clearly records forest clearance and pasture development. In cores 1 and 2 (hillside) it registers the removal of local trees, but the oak pollen in cores 3-6 does not reflect trees at the sampling sites. This pollen blew onto the open meadow from oaks on adjacent hillsides (Janssen 1973:40). In cores 3, 4, (dry flats) and 5 (moist flats), agricultural development is most clearly recorded in the decline of local herbs and small trees and shrubs, such as meadow rue, goldenrod, ironweed, holly, and alder. The installation of drains and the re-routing of the creek bed are registered in the decrease of sedges in cores 5 and 6 (wet flats). Because these 19th century agriculture-related changes in the flora are recognizable in the cores, they can easily be factored out of the analysis in order to focus on the 18th century vegetation recorded in the deeper portions of the cores.

A distinct series of vegetation changes correlated with local topography is evident among the pre-agricultural period spectra in the Great Meadows core transect. To make it easier to visualize the primordial vegetation, the pre-clearance/pre-drainage pollen spectra in each core are combined as single samples, and presented in order down the hillside and across the meadow in Figure 2.

Oak pollen is the most common type in all cores. It is most prominent in cores 1 and 2, and these counts reflect oak-dominated forest covering the western hillside above the meadow. The lower, relatively uniform oak percentages of cores 3-6 record the background oak pollen contribution that was homogenized while being wind-transported onto the treeless meadow (Janssen 1973:40). The relatively high hickory (*Carya*) and red maple (*Acer rubrum*-type) counts of cores 1 and 2 indicate that these trees were present among the oaks on the western slopes. The slightly higher beech (*Fagus*) and birch (*Betula*) percentages of cores 1-4 suggest a local, rather than an extra-local or regional, pollen source. They probably reflect the presence of a few trees of this kind on the western side of the meadow near--just outside perhaps--the treeline of the oak-dominated forest.

Alder (*Alnus*) pollen percentages rise and fall in a bell-shaped curve from core 1 to core 6. They peak where the oak contribution falls off in core 3, suggesting that most of this pollen came from an alder population situated between the tall forest and the grass-dominated portion of the meadow. The largest percentages of black locust-type and holly pollen also were found in this segment of the core transect (cores 3-5), and a few of these trees must have been scattered about the meadow between the forest proper and the marshy area near the fort.

The pollen contributions of pine (*Pinus*), hazel (*Corylus*), hemlock (*Tsuga*), spruce (*Picea*), walnut (*Juglans*), blue beech/hornbeam (*Ostrya/Carpinus*), sugar maple, (*Acer saccharum*), ash (*Fraxinus*), willow, (*Salix*), and poplar/cottonwood (*Populus*), all increase in cores 5 and 6, nearest the fort. Mesic taxa, such as cottonwood or willow, may have been growing at the lowest part of the meadow, but it is unlikely that many of the other trees were rooted here. The fort was closer to the eastern side of the meadow than to the western side, and it is probable that this pollen was blown from trees growing on the eastern slope above the fort. This suggests that the composition of the forest on the eastern side of the meadow was more diverse than that of the western side. Such an interpretation also is consistent with an 1822 report stating that stands of pines, considered unusual for the

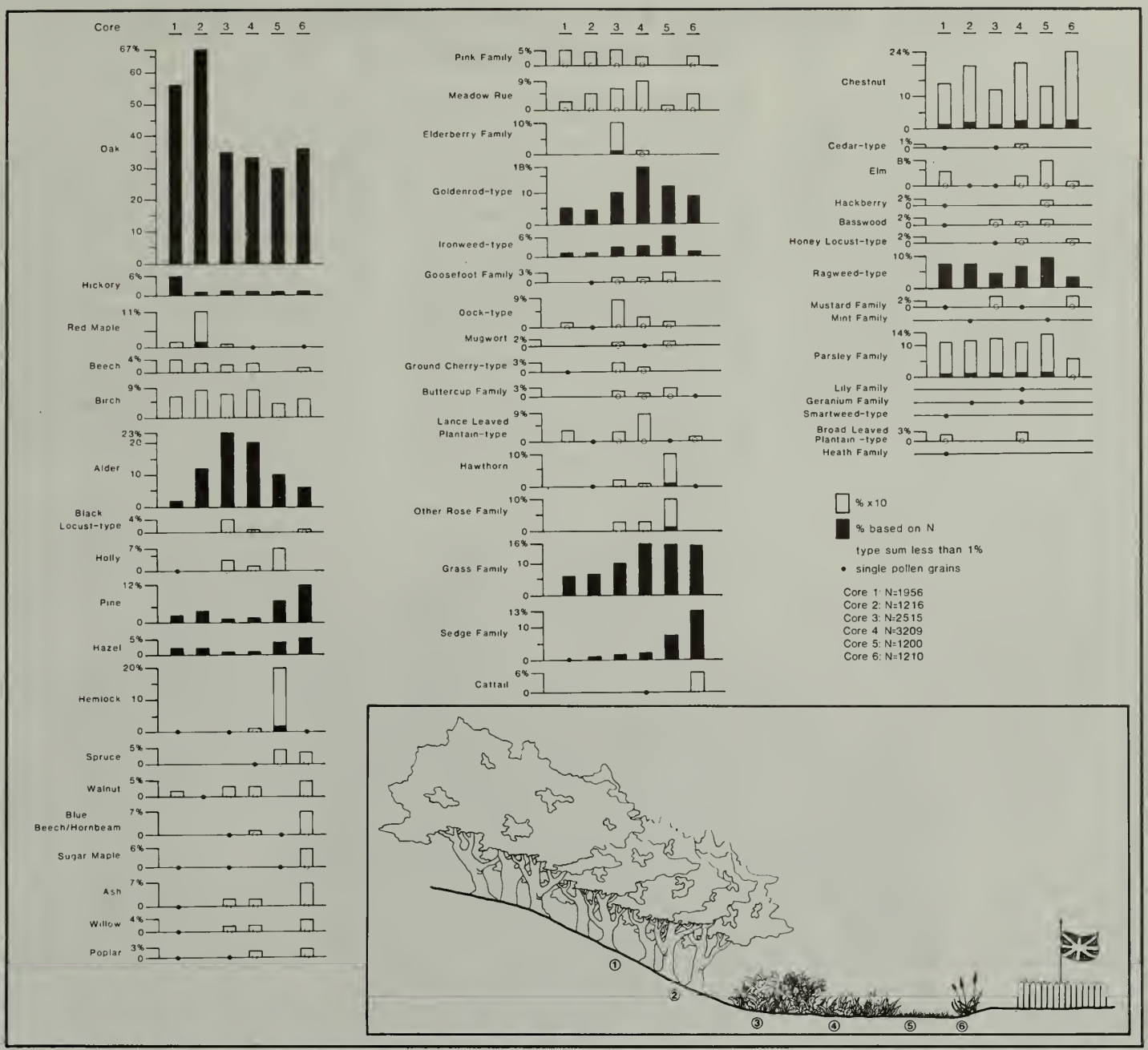

Figure 2. Pollen percentages of pre-clearance pollen samples of the Great Meadows cores presented in topographic order down the hill and onto the meadow.

Figure 3 (inset). Stylized artist's conception of the Great Meadows in 1754

area, occupied the slopes of Laurel Hill to the east of the meadow (Torres-Reyes 1970:10).

Among the non-arboreal pollen types, only that of the pink family (*Caryophyllaceae*) was more common among the oaks (cores 1 and 2) on the western slope than on the meadow. The presence of more grass (*Gramineae*) among the alders at the forest edge is indicated by the increase in this pollen type in core 3, and the extent of the meadow proper is recorded by the high, uniform grass pollen percentages of cores 4, 5, and 6. The remaining non-arboreal pollen types, sedges excepted, were clustered in cores 3, 4, and 5. Some of these--elderberry family (*Caprifoliaceae*), hawthorn (*Cratageus*), and other members of the rose family (*Rosaceae*)-are from woody shrubs, and probably record the sort of "bushes" that Washington ordered removed to deny cover to potential attackers (Fitzpatrick 1931/1944:I:54). Some non-arboreal types--meadow rue (*Thalictrum*), goldenrod-type (*Solidago*-type), ironweed-type (*Chicoreae*), goosefoot family (*Chenopodiaceae*), and dock-type (*Rumex mexicanus*-type)--record the presence of relatively tall non-woody herbs. Others--mugwort (*Artemisia*), ground cherry-type (*Physalis*-type), buttercup family (*Ranunculaceae*), and lance-leaved plantain (*Plantago lanceolata*-type)--reflect lower growth. A similar plant assemblage has taken over the meadow since the Park Service stopped mowing. The grasses, although dominating the near-surface pollen spectra, since they now constitute an understory beneath the tall herbs on the dry portion of the meadow proper, may not have been highly visible in 1754.

Rising frequencies of sedge (*Cyperaceae*) pollen--a poorly disperse type (Handel 1976:422)--in cores 5 and 6 and the presence of a few cattail (*Typha*) pollen grains in core 6 indicate that the ground became progressively wetter nearer the fort. The pollen contributions of most herbs, including those uniformly distributed across the rest of the transect (Fig. 2, right column) were depressed in these cores, and the ground must have been too marshy for anything but sedges and grass.

Continued on page 10

Subalpine Meadows: A Promising Indicator of Global Climate Change

By Andrea Woodward and June Rugh

As one of a number of projects funded by the NPS Global Change Program, the University of Washington Cooperative Parks Study Unit (UW CPSU) has chosen to study tree establishment in subalpine meadows. Studies underway at Olympic and Mount Rainier National Parks include two that examine the relationship between climate and tree establishment; others focus on establishment after fire, seedling establishment in relation to substrate, and soil development as a result of tree establishment. It is hoped that these projects will give park managers tools to understand and interpret for the public the dynamics and consequences of change in subalpine areas, as well as the vital role these areas play in detecting global climate change.

Background

Climatic variation is integral to the Earth's history, with changes generally occurring on the scale of centuries or millennia. However, atmospheric changes following the Industrial Revolution--specifically, the atmospheric concentrations of CO_2 and other greenhouse gases--may produce rates of global climate change unprecedented since the last Ice Age. One aspect of this change involves the earth's mean surface air temperature, which already has increased approximately 0.6 C. since 1880 (Hansen and Lebendeff 1988) and is predicted to rise 1 to 5 C. during the next century (Schneider 1989). Although seemingly small, this increase would have far-reaching consequences; significantly, it is of the same magnitude as the 3 to 5 C. change in average temperature that occurred between the height of the last Ice Age and the present (Schneider 1989). Precipitation patterns are expected to change as well; however, the complexity of the hydrologic cycle makes prediction in this area more difficult.

It is intuitively clear that this changing climate will affect the biosphere, including the distribution of vegetation. One way to conceive of the effect of global change on vegetation distribution is to think of plant communities as grouped into vegetation zones appearing as distinct bands along elevational and latitudinal gradients (a useful idealized scheme; Peters 1990) and then imagine these zones shifting to new locations. There is, in fact, evidence that distribution of tree species has altered in response to changing climate in the present century (Franklin et al. 1971), as well as over the period following the last Ice Age (Brubaker 1988). However, such vegetation changes are much more complex than the migration of intact plant communities, or the shifting of vegetation zones to higher elevations and latitude in response to warmer climates; crucial factors include disturbance history, substrate availability, seed source, current conditions and the adaptations of individual species. In some places, trees may eventually be replaced by meadows, if conditions change to favor meadows.

Moreover, the accurate *detection* of vegetation change presents a tough challenge. First, to discern significant changes within the high variability of biological systems requires large sample sizes over time and space. Second, the processes of biological change operate on diverse time scales. For example, while tree establishment in subalpine meadows may happen on a scale of years, their presence might not be noticeable for decades due to the slow growth typical of higher altitudes. In contrast, redistribution of species in the adjacent montane zone depends on disturbance frequency, which generally is measured in centuries. Finally, it can be hard to find a distinct division between one vegetation zone and another because where zones meet, the vegetation types characteristic of each zone can overlap.

Such problems associated with detecting vegetation change can be avoided by studying the subalpine, an area uniquely suited to the study of global climate change. Here, where meadows are punctuated with clumps of trees, there is a distinct line between vegetation types. Also, the process of tree establishment in subalpine meadows is sensitive to climate, particularly to the winter snowpack of the Pacific Northwest. Finally, the subalpine allows researchers to examine the effect of climate patterns on vegetation on a yearly basis (by correlating annual weather patterns with tree age), rather than having to rely solely on the larger patterns of climatic trends.

In order to seize the unique opportunity to study vegetation in relation to climate provided by the subalpine zone, the UW CPSU is cooperating on several research projects.

Pollen Analysis in Historical Landscape Studies continued from page 9

The current Fort Necessity core series indicates that the western hillside above the meadow was covered by an oak-dominated hardwood forest (cores 1 and 2), that the ground near the fort (cores 5 and 6) was a marsh dominated by sedges and grass, and that a mixture of shrubs and herbs, with a grass understory, occupied the portion of the meadow between the oak forest and the marsh (cores 3, 4, and 5). There were more alders at the fringe of the forest while grass, meadow rue, goldenrod, and ironweed were thickest on the dry ground closer to the fort. The forest on the eastern side of the meadow also differed in composition from the forest on the west.

A stylized artist's conception of the battle-era vegetation is presented in Figure 3. The pre-clearance pollen spectra indicate that it will be possible to reconstruct the battle-era vegetation on Great Meadows with an acceptable degree of accuracy.

The next step in the investigation will be to fill in the gaps in this core series and to take core transects to the south, east, and north of the fort. The pollen signatures of agricultural development at different elevations on and around Great Meadows have been established in this core series. In future investigations only the deeper, pre-agricultural sediments need be investigated.

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In both Mount Rainier and Olympic National Parks we have established transects from forests into meadows and aged trees along these transects. At Olympic NP, study sites are arrayed along a precipitation gradient from the wettest to driest regions. From these studies we hope to learn how regional and local climate patterns affect the distribution of trees and meadows in the subalpine.

Management Implications

Vegetation change in the subalpine areas of national parks has important consequences for management. Typically, subalpine meadows are popular with park visitors because of their wildflowers and vistas, and many park facilities have been created to accommodate this demand. If these meadows start to shrink, park managers will need to decide how to handle greater concentrations of people in these already fragile areas. If subalpine meadows disappear altogether, the adjacent facilities will need to be redesigned or relocated.

To envision and interpret such transformations in the face of predicted global climate change is a major challenge within NPS. Biological changes that appear to proceed slowly, in human terms, will be difficult to accept if they accelerate in the future. A primary aim of the current global change research in subalpine areas is to assist park staff in making informed management decisions as parks are impacted by these changes, and in gaining public support for those decisions.

Woodward is a Research Biologist and Rugh is a Technical Writer with the NPS/ CPSU at the University of Washington.

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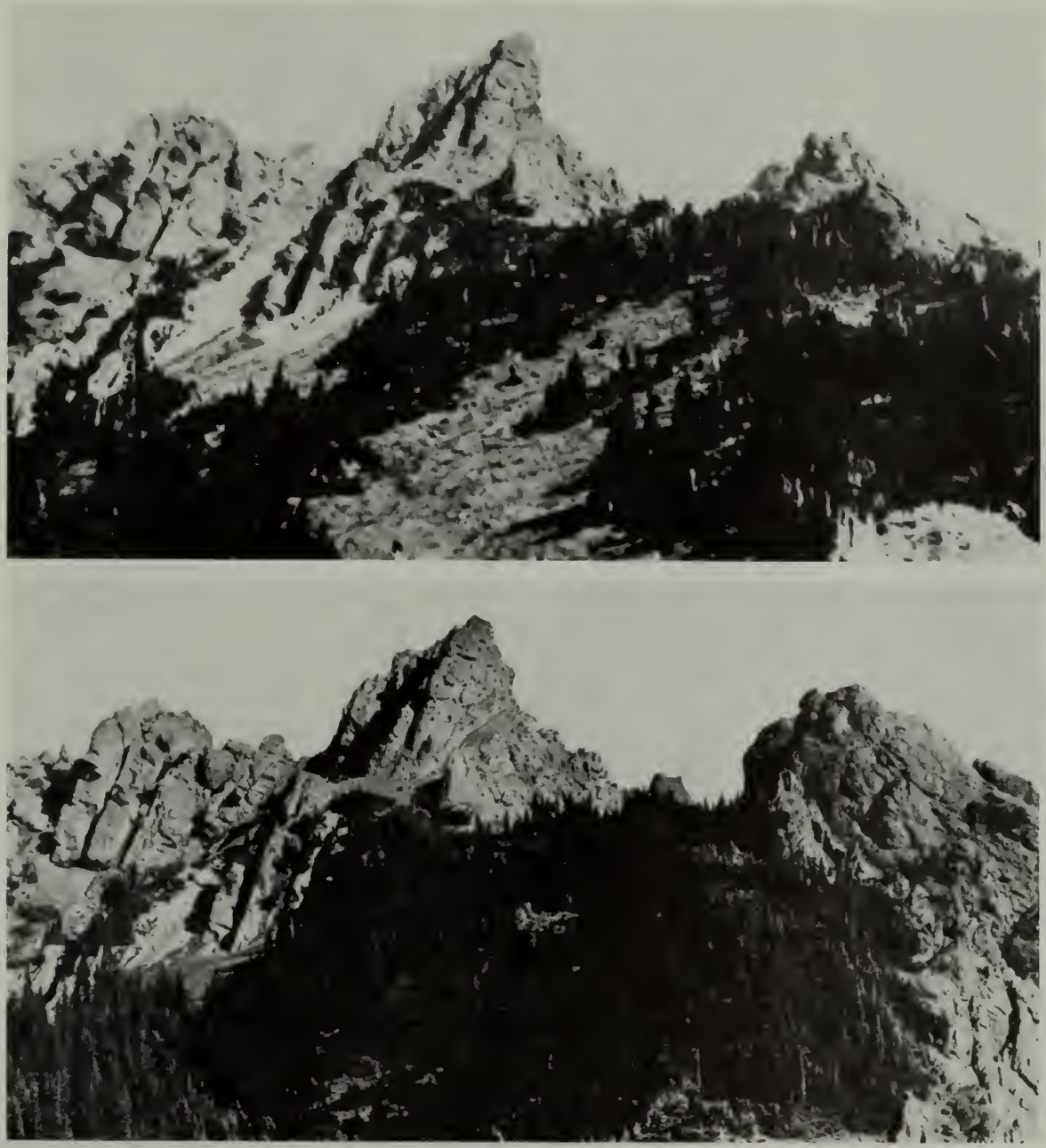

At least 70 years separates these two views of Mount Angeles in Olympic NP. The top photo was taken between 1915 and 1920. The lower view, taken in 1986, shows tree establishment in areas that formerly were meadow.

Southwestern Willow Flycatcher Declines In Grand Canyon National Park

By Matthew J. Johnson, Laura E. Ellison, and Mark K. Sogge

The southwestern willow flycatcher (*Empidonax traillii extimus*) is a riparian obligate species whose population has severely declined in recent decades. Factors in the decline include loss and fragmentation of riparian habitat, loss of wintering habitat, increased invasion of riparian corridors by the exotic tamarisk (*Tamarix spp.*), brood parasitism by brown-headed cowbirds (*Molothrus ater*), and predation (Whitfield 1990, Harris 1991, Rosenberg et al. 1991).

Field researcher records the song of a willow flycatcher.

The states of Arizona, New Mexico, and California comprise most of the southwestern willow flycatcher's historic and current range. Each of these states list the subspecies as endangered (Arizona Game and Fish Department 1988, New Mexico Department of Game and Fish 1988, California Department of Fish and Game 1991). In addition, the bird is listed by the USFWS as a candidate category 1 species (56 FR 58804). The USFWS was petitioned in January 1992 to list the subspecies as endangered.

Although once distributed along most major river systems in Arizona (Phillips 1948, Unitt 1987), only three areas are known to have been occupied by nesting southwestern willow flycatchers in the past 10 years. These are the lower San Pedro River, the Verde River, and the Colorado River in Grand Canyon NP (Hunter et al. 1987, Unitt 1987, Brown 1988, and USFWS unpublished data). Of these areas, Grand Canyon NP hosted the greatest number in the 1980s, with a maximum estimate of 11 males in 1986 (Brown 1988). However, this small number had declined in recent years to only two singing males (pairs) in 1991 (Brown 1991).

The southwestern willow flycatcher is a neotropical migrant that arrives in the Grand Canyon around May of every year. The breeding season continues through July and has been known to last through the first week of August. Nesting sites in the Grand Canyon are mainly confined to an introduced shrub, tamarisk (*Tamarix ramosissima*). Of 12 nests studied from 1986 to 1988, all were located in tamarisk (Brown 1988). In addition, marsh plants such as cattails (*Typha spp.*) are often part of their territories and foraging habitats (Unitt 1987).

Clutch size of southwestern willow flycatchers along the Colorado River is typically smaller than in other races of the bird: Of 28 unparasitized nests, 18 percent had two eggs, 82 percent had three eggs, and none had four (Brown 1988).

The willow flycatcher song, a "fitz-bew," distinguishes it from several other hard to identify *Empidonax* species. This flycatcher also produces a "whit" call in conjunction with the "fitz-bew," which it will use during defense of its nest or territory. Singing begins in the spring as soon as the birds arrive and establish their breeding territories, and usually ceases in July, well before their fall departure.

Breeding habitat in the Grand Canyon, preferred by the southwestern willow flycatcher.

Southwestern willow flycatcher surveys were conducted along the Colorado River within Grand Canyon National Park from mid-May through July, 1992 to determine presence and abundance of this declining subspecies. These surveys were coordinated by the NPS/CPSU at Northern U/AZ, and were a cooperative effort among the NPS, USFWS, Bureau of Reclamation, and the AZ Game and Fish Dept. Hualapai Tribe. Willow flycatcher presence was determined by sightings and song detections made from approximately 5:30 to 11 a.m. daily, when male song-rates are typically greatest (Unitt 1987). In some cases, surveys were also conducted at dusk, a period during which willow flycatchers may display a secondary peak of singing (Weydemeyer 1973). In order to maximize the likelihood of detecting willow flycatchers, surveyors used tape-broadcast songs of willow flycatchers--a proven method for eliciting a vocal response from nearby resident flycatchers (Seutin 1987, Craig et. al 1992).

Once flycatchers were detected, they were observed very closely in order to determine breeding activity. Male singing rates (songs/minute) were recorded during this observation period to provide information on daily and seasonal variation in song-rates. Nesting status was verified by inspection of the nests and then by re-inspection on subsequent survey trips. Clutch size, number and age of young, and presence of cowbird eggs or young were also noted.

During 1992, agency personnel and experienced volunteers conducted over 256 hours of surveys in 132 habitat patches along the Colorado River corridor. Only seven southwestern willow flycatchers were detected. Two pairs were found at Cardenas Marsh (River Mile 71.1). One of these pairs produced a complete clutch of three eggs with no evidence of brood parasitism by brown-headed cowbirds. Three healthy nestlings from this clutch were observed in late June, and a juvenile and an adult were detected foraging during a third visit in late July. Unfortunately, the second pair showed no sign of successful breeding. Three unpaired willow flycatchers also were observed at different sites along the river corridor. Since the Grand Canyon is part of a migratory route for other races of willow flycatchers, these three unpaired birds could possibly be migrant visitors. However, these birds were observed in the same habitat patch on consecutive days, and the sightings occurred when migrants were no longer expected within the park.

Vocalization and habitat use information were collected on the willow flycatchers found at Cardenas Marsh. Data were gathered on male song rate to determine differences in daily and seasonal song frequency. A parabolic recorder was utilized to tape vocalizations by the male and female flycatchers responding to the tape broadcast. The recorded vocalizations will be sent to the Borror Lab of Bioacoustics at Ohio State University, where specialists will determine if the southwestern willow flycatcher vocalizations differ from those of the other subspecies.

Several factors could explain the decline of the southwestern willow flycatcher along the Colorado River in the last two decades. These factors include cowbird parasitism and a variety of human-related disturbances. Although we found no evidence of brown-headed cowbird eggs or nestlings inhabiting willow flycatcher nests during this study, approximately half of the nests examined during the 1980s in the same study area were parasitized by cowbirds (Brown 1988). The cowbird population in the canyon is large, and poses a threat to many birds. Cowbird control is just one option that may be beneficial to the willow flycatcher, and to many other highly parasitized birds of the Grand Canyon.

Fluctuations in flow release from Glen Canyon Dam also may affect the numbers of southwestern willow flycatchers along the Colorado. Long-term indirect habitat changes brought about by controlled flows (e.g. habitat expansion or fragmentation, changes in plant species composition, and changes in patch size or configuration) could affect willow flycatcher breeding ecology by increasing or decreasing suitable habitat.

Human-related activities along the river corridor also could affect this sensitive bird. Recreational use of the canyon can impact flycatchers by direct degradation of riparian habitat, or disturbance from noise and activity associated with nearby campers. Although the willow flycatcher is one of seven species negatively associated with campgrounds in riparian areas in northern Utah (Blakesley and Reese 1988), the birds have been found near campsites along the Colorado River corridor. The fact that these birds are found near campers may suggest they are tolerant of nearby human activity. However, repeated human presence within a territory or close to an occupied nest could cause the birds to abandon a territory or nest.

Grazing has been shown to reduce the quality of riparian flycatcher habitat (Taylor 1986, Sanders and Fleet 1989). Although grazing is not a direct threat to riparian corridors within Grand Canyon NP, grazing does occur directly adjacent to the park on some lands near the park, and could be affecting the regional flycatcher population by reducing potential habitat.

The possibility of listing the southwestern willow flycatcher as an endangered species, coupled with its small population size and apparent widespread decline, demonstrates the need for continued monitoring along the Colorado River corridor. Future willow flycatcher surveys will provide valuable information needed to continue monitoring population trends, and will further define habitat use along with potential threats.

Johnson is an ecologist and Ellison and Sogge are biological technicians with the NPS/CPSU at Northern U/AZ.

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Notes from Abroad

Editor's Note: Carol L. McIntyre, Wildlife Biologist with the NPS Alaska Region, in May 1992 attended the Fourth World Conference for Birds of Prey and Owls. The meeting, held in Berlin, Germany, was organized by the World Working Group for Birds of Prey and Owls, an international working group dedicated to the conservation of birds of prey throughout the world. Here is her report.

Surprisingly, I was the only representative from Alaska and one of only 5 women who presented papers to the conference of more than 400 participants. The major emphasis of the conference focused on declining raptor populations worldwide, and conservation and research efforts on behalf of raptors in eastern Europe. The sessions covered the following topics:

Population studies; aspects of long-term changes in numbers and distribution of raptors and owls; biology and conservation of the large falcons in the subgenus *Hierofalco*; trapping, marking, and radio-tagging techniques; environmental contaminants and raptors; declining raptor populations: their biology and conservation; reintroduction of eagles, vultures, and other raptors; population ecology of owls; the systematics and taxonomy of raptors; tropical rain forests and raptors; and the biology of extirpated, rare, or lesser-known owls.

The two papers I presented were "Reproductive performance of golden eagles in Denali National Park and Preserve, Alaska" and "Distribution, status, and aspects of the breeding biology of gyrfalcons in Alaska," co-authored with Ted Swem, USFWS; Bob Ritchie, Alaska Biological Research; Peter Bente, USFWS; and Dave Roseneau, Biosystems Consulting. The first paper was one of several presented on long-term ecological studies of golden eagles, however it was the only paper presented on golden eagles in North America and one of the few papers on a non-declining population of golden eagles. The second paper included results of gyrfalcon surveys and population monitoring at Denali. It was presented in a series of papers focusing on status and distribution of gyrfalcons throughout North America, and included presentations by K. Poole on the Northwest Territories, D. Mossop on the Yukon Territory, and M. Fuller on western Greenland.

Both of my papers were well received and stimulated good discussions. Of particular interest were the field techniques and data collection methods used for the Denali project. Biologists were excited and pleased to learn that the NPS is taking a lead role in raptor research in Alaska, and encouraged me to continue my studies on reproductive success of golden eagles and migratory movements of golden eagles in Alaska.

I participated in two field excursions. One was a visit to a newly created UNESCO biosphere reserve, Oberspreewald, in eastern Germany. This BR contains one of the largest wetlands in eastern Europe and provides breeding habitat for many bird species, including the rare Black Stork. A large number of raptors also nest in the Spreewald. One of the most interesting components of the reserve is the initiative taken to preserve the area's cultural resources, which include numerous small farming communities where farming is still small scale and conducted mainly by hand and animal power. I spent 2 days visiting conservation areas in the new federal province of Mecklenburg in northeastern Germany. Of particular interest was a visit to a small fish farm in Muritz, where we observed one of the largest concentrations of white-tailed sea eagles. We also visited a breeding area of the endangered lesser spotted eagle.

During the Mecklenburg excursion we attended a reception by the Minister of the Environment in Mecklenburg, who expressed her appreciation for our visit and described current conservation efforts in the province.

These field trips enabled me to observe wildlife and natural areas in the former East Germany, and to visit areas where westerners are only beginning to travel. It was instructive to see the extent of recent westernization in a former Soviet Bloc country and surprising to see large areas of undeveloped land, where wildlife seems to be abundant. However, a challenge awaits conservation groups in eastern Germany, where the influx of modern agricultural and industrial practices will change the landscape and where the desire for a high standard of living will prevail.

The conference and field excursions made it possible for me to meet with biologists from Scotland, Spain, Germany, Portugal, Yugoslavia, Netherlands, France, Bulgaria, Norway, Sweden, Finland, Siberia, Byelorussia, the Kola Peninsula, Kamchatka, Australia, South Africa, Canada, Israel, Japan, Cuba, and Taiwan. These contacts will be useful for the advancement of raptor research projects in Alaska, particularly through peer review of study designs and research proposals and by continued exchange of technical information.

Letters

I am a reader of *Park Science* and a tree farmer, intensely interested in the evolving land management scene. I recently attended a conference in Portland, OR, that I think would be of interest to your readers. It was sponsored by the Western Forestry and Conservation Association and titled "Science and Politics in the Practice of Forestry." The keynote address, by Washington State Commissioner of Public Lands Brian Boyle, stressed the current clash of **values**, not of **facts** in the field of natural resource management. He suggested that regulations tie our hands, whereas cooperation has a freeing effect.

Tom Nygren, USFS Regional office in Portland, suggested that science only looks at pieces, whereas managers must use more holistic thinking to do their jobs. George Frampton, president of the Wilderness Society, focused on the need for developing consensus.

Technical sessions on land use, stand management, wildlife, reforestation, fire, forest health, all stressed the need to better educate the public and decision makers about what we **think** we know, and more particularly to educate them about what we **don't** know. Only the session on economics left this observer wondering if most economics isn't really in the realm of guesswork.

Some 65 or more speakers generally stressed the need for more holistic thinking by managers, more cooperation among agencies, and a more informed body politic. Many speakers recognized that good science is necessary in the practice of resource management, but that science alone is not sufficient.

William H. Oberteuffer
Smilin' O Ranch
Elgin, OR

Index for Volume 12

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Closer Ties Sought

The goal of the 1993 Cultural and Natural Resources Workshop scheduled for April 18-23 at Death Valley National Monument is to strengthen the cultural and natural resource programs in Western Region parks and to promote closer ties between cultural and natural professionals by developing interdisciplinary approaches to problem solving. "Sand, Stampmills, and Sidewinders" is the title chosen for the week-long workshop.

New Mountain Journal Originates in Slovakia

From Cliff Martinka, Senior Research Scientist at Glacier NP, comes word of a new journal, *Oecologia Montana,* which originated in 1992 at National Park High Tatras in Czecho-Slovakia. Dr. Marian Janiga of the park's Research Coordination Center, is editor-in-chief. The journal's aim is to protect mountains and learn how interactions between human development and mountain ecosystems can be better managed.

Oecologia Montana will publish articles ranging from forestry to alpine research. It will be an international medium in all fields of mountain ecology and will include information about both "Eastern" and "Western" ecological research.

Martinka is represented in Vol. 1, No. 1, with an article entitled "Conserving the natural integrity of mountain parks: Lessons from Glacier National Park, Montana." In it, he reviews the history of Glacier NP and describes recent peripheral development, ecological isolation, landscape fragmentation, and special designations posing risks and establishing values that call for a new management paradigm--one based on a regional ecosystem model. He points to the prospect of global change as adding the dimension of permanent environmental change to the increasing complexity of park conservation.

Manuscripts within the journal's scope will be reviewed by at least two referees and authors generally will be notified of acceptance or rejection within three months. The journal's language is English. Dr. Janiga's address is High Tatras NP, Research Coordination Center, 059 60 Tatranska Lomnica, Czecho-Slovakia.

Meetings of interest

1993

April 18-23 WESTERN REGIONAL INTEGRATED CULTURAL & NATURAL RESOURCES WORKSHOP, at Furnace Creek Ranch, Death Valley National Monument. WRO Contacts: Jonathan Bayless, (415)744-3968, and Gene Wehunt, (415)744-3957.

May 17-21 NATIONAL INTERAGENCY WILDERNESS CONFERENCE, Tucson, AZ. Focus on 3 stewardship themes: (1) Wilderness Restoration--minimum tool use in alien plant species control and reveg; (2) Complementary Management of wilderness and archaeological, historical, and cultural resources, and (3) Emerging Challenges: cultural diversity, demographic trends, adjacent land uses, day use, outfitter policies, and access for the disabled. Contact: Alan Schmierer, WRO (415)744-3959.

June 22-25 CONSERVATION IN THE WORKING LANDSCAPES, the 1993 Natural Areas Conference, at Univ. of Maine, Orono, ME. Symposia topics: Biological diversity in working landscapes (total perspective and institutional perspective), conservation in marine ecosystems, inventory and monitoring natural landscapes in working landscapes, conserving endangered species and natural communities in working landscapes, and managing natural areas in working landscapes. Contact: Hank Tyler, Maine State Planning Office, Station 38,. Augusta, ME 04333; (207)624-6041.

Aug. 24-26 12th WILLIAM T. PECORA REMOTE SENSING SYMPOSIUM, "Land Information from Space-Based Systems," Sioux Falls, SD. Sponsored by the USGS in cooperation with other federal agencies. Contact: Dr. Robert Haas, Symposium chair, 605-594-6007 or Dr. James W. Merchant, Program chair, 402-472-7531, FAX 402-472-2410.

1994

June 7-10 FIFTH INTERNATIONAL SYMPOSIUM ON SOCIETY AND RESOURCE MANAGEMENT, CO/State/U, Fort Collins, CO. Michael J. Manfredo, Program chair, has issued a call for papers, to be submitted by Nov. 1, 1993, to Manfredo, Human Dimensions in Natural Resources Unit, CO/State/U, Fort Collins, CO 80523.

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Pacific Northwest Region

An article by Seth Tuler, Gary Machlis, and Roger Kasperson, "Mountain Goat Removal in Olympic NP: A Case Study of the Role of Organizational Culture in Individual Risk Decisions and Behavior," appeared in the Fall 1992 issue of *Risk: Issues in Health & Safety. Risk* is a refereed, interdisciplinary quarterly that explores basic policy issues related to public and private efforts to manage science and technology for net reduction in the probability, severity, and aversive quality of health and safety impacts on individuals and institutions. Reprints of the article are available from Dr. Machlis at the NPS/CPSU, Dept. of Forest Resources, University of Idaho, Moscow, ID 83843.

* * *

A listing of recent publications relevant to natural resource issues in the Region is available at irregular intervals from the PNR Library. Kathy Jope, PNR Resource Management Specialist, compiles the list and contributes abstracts of many of the titles. Those interested in being on the mailing list for the Current Literature lists may contact Jope at (206) 553-5670.

* * *

The Olympic Natural Resources Center on the Olympic Peninsula adjacent to Olympic NP is now issuing a quarterly bulletin, **Update**, started in Summer 1992 and edited by Kathyrn A. Kohm, Olympic Natural Resources Center, U/WA, AR-10, Seattle, (206)685-4802. The Center was created in 1989 by the Washington State legislature, which envisioned the Center as both a program and a facility. The 1991-3 state budget provided funds to build the research facility. Olympic NP Supt. Maureen Finnerty is a member of the Governor's Policy Board; Dr. Jerry Franklin is the Center's Director. For information on the facilities' plans, contact Gordon Smith, U/WA AR-10, Seattle, WA 98195; (206) 685-4802.

* * *

Mount Rainier NP has given Carolyn Driedger Mastin of the USGS David A. Johnston Cascades Volcano Observatory a monetary award in recognition of the superior support she has provided the park for the past decade. Driedger Mastin has assisted in geologic, geomorphic, and glaciologic resource information since the mid-1980s, providing annual training to park interpretation and natural resource divisions. She continues to give technical advice in the park's monitoring of the Nisqually glacier and has prepared an updated interpretive bulletin on the status of park glaciers.

* * *

A draft science plan for the Mount Rainier Decade Volcano has been submitted to the National Academy of Science for initial review. No decisions have yet been made about future activities. The draft science plan contains a section on mitigation, including discussions on living safely in the shadow of Mount Rainier and the Washington State Growth Management Act. At least 8 of the 40 pages are devoted to studies related to social consequences of a Mount Rainier eruption. It is intended that a series of "spin-off" meetings devoted entirely to sociologic studies will occur after the completion of the final science plan, which should be published by April 1993.

Rocky Mountain Region

Dr. Stanley Ponce has been named A/D for Resources Management and Research in the Region. His focus is on issues related to both natural and cultural resource management and research, and he believes strongly in "programmatic" management. He feels that much of the NPS effort presently is "issue" based and lacks continuity from year to year. "A good program," Ponce said, "requires sound information about the condition of the resources, an understanding of the processes associated with these resources, the potential threats to these resources, and capable people who can interpret this information and manage the resources effectively."

* * *

Three of the Region's new Global Climate Change research initiatives approved for FY 93 are for Colorado Rockies, Glacier, and Central Grasslands. All three complement existing projects and provide the means to merge RMR programs with other regions and agencies.

* * *

In order better to address resource management and research needs, the Regional Office has reorganized as follows: The cultural and natural resource management and research functions have been combined into a new Directorate of Resource Management and Research, comprised of three divisions: Cultural Resource Management, Natural Resource Management, and Research. A Directorate Office of Resource Data Management and GIS serves the needs of all three Divisions as well as RMR parks and other RMRO directorates.

The Directorate currently is developing a Strategic Plan, a basic philosophy of which is that parks are shareholders and customers of the Directorate, and that the Directorate will strive to provide them with outstanding, proactive, professional products and services. Recommendations from the Vail Conference report and the National Research Council's Science and the National Parks report are being used to develop the Plan and as guidelines for the new RMR Directorate.

* * *

To improve park research as recommended by the National Research Council, the RMR is strengthening and expanding its CPSU program. CPSUs will be developed to meet the needs of groups of parks within the same ecosystems and/or as thematic research centers. The tri-regional CPSU at Northern AZ/U will retain its focus on Colorado Plateau parks. The CO/State/U CPSU will focus on sustainable ecosystem management issues at park units in the Central Rockies and Grasslands. The old (1974) U/WY NP Research Center will be reshaped as a "traditional" CPSU, with focus on the Greater Yellowstone Ecosystem. The unstaffed units at MT/State/U and U/MT will be staffed with unit leaders and former park research positions. The MT/State/U CPSU will cooperate with the U/WY in focusing on the Greater Yellowstone Ecosystem while the U/MT will focus on the Northern Continental Divide Ecosystem, primarily Glacier NP. Each CPSU in the Region will have a biogeographical focus as well as an issue-related theme.

* * *

Researchers Ken Driese and Don Roth recently completed a baseline study of the vascular flora, mammal fauna, and human disturbance level on the tower summit at Devil's Tower NM. They identified and quantified coverage for 21 plant species. Total cover for the 9 grass species, 8 shrub species, and 4 forb species was 51 percent. Although summit vegetation was dominated by grasses, bare rock comprised the greatest cover class.

During the three June through September monitoring periods, the percent of disturbed vegetation was 9, 13, and 16 percent. Three small mammal species were identified. Populations were estimated at 45 deer mice (*Peromyscus maniculatus*) and 12 bushy-

tailed woodrats (*Neotoma cenera*). Only three yellow-pine chipmunks (*Eutamias amoenus*) were trapped, too few to estimate the population.

Southeast Region

South Florida will be served by two new CPSUs, each operating within its particular academic specialty areas. Florida International University (FIU) and the University of Miami (UM) have been designated as unit locations. FIU will act as lead unit, with Mike Soukup as director, supervising and coordinating activities at both university units.

* * *

Bob Warren, Director of the U/GA CPSU, gave a presentation in Washington DC to the International Assn. of Fish and Wildlife Agencies' subcommittee on Wildlife Contraception. This group's task is to advise state and federal wildlife agencies on regulatory concerns and the practicality of applying contraceptives to free ranging wildlife populations. Dr. Warren was added as a subcommittee member.

* * *

John Peine of the U/TN CPSU has received a certificate for 20 years of continuous service as an NPS Research Ecologist.

* * *

Recently published reports include:

Bythell, J.C., E. Gladfelter, and M. Bythell. 1992. Ecological Studies of Buck Island Reef National Monument, St. Croix, U.S. Virgin Islands: A Quantitative Assessment of Selected Components of the Coral Reef Ecosystem and Establishment of Long-Term Monitoring Sites, Part 2. USDI, NPS, Island Resources Fdn., St. Thomas, U.S. Virgin Islands, and West Indies Lab, St. Croix.

DeVries, D. and R.F. Doren. 1992. Melaleuca Annual Report. S/FL Research Center, Everglades NP.

Lauritsen, D.C. 1993. Assessment of the Hard Clam, Mercenaria, in Cumberland Sound, GA. Kings Bay Environmental Monitoring Program Report, U.S. Dept. of the Navy, Naval Facilities Engineering Command, Washington DC, KBEMP-91-03. U/GA CPSU, USDI, NPS.

* * *

Articles published recently are:

Bratton, S.P. Alternative Models of Ecosystem Restoration. Published in Ecosystem Health: New Goals for Environmental Management, edited by Robert Constanza, Bryan G. Norton, and Benjamin D. Haskell. Island Press, Washington DC; Covelo, CA.

Miler, S.G., S. Bratton and John Hadidian. 1992. Impacts of White-tailed Deer on Endangered and Threatened Vascular Plants. Natural Areas Journal, Vol. 12(2).

* * *

The following reports were received:

Johnson, B.R. 1992. Mitigation of Visitor Impacts on High Montane Rare Plant Habitat: Habitat Protection Through an Integrated Strategy of Design, Interpretation and Restoration, Craggy Gardens, Blue Ridge Parkway, NC. U/GA.

Sargent, R.A. 1992. Movement Ecology of Adult Male White-tailed Deer in Hunted and Non-hunted Populations in the Wet Prairie of the Everglades. U/FL.

Boulay, M.C. 1992. Mortality and Recruitment of White-tailed Deer Fawns in the Wet Prairie/Tree Island Habitat of the Everglades. U/FL.

Western Region

From Malinee Crapsey, editor of **Sequoia Bark**, an intermittent publication of Sequoia and Kings Canyon NPS, come three recent issues highlighting research on Emerald Lake (aimed at determining if acid rain is a threat to Sierran lakes), tree rings research (to determine whether, in the light of a 1000-year record of temperature and precipitation in the Sierra Nevada, the current conditions constitute a drought or whether the current drought constitutes the norm), and "techno-mapping" (a look at both the dark and bright sides to Geographic Information Systems and particularly at the "adolescent" stage of Sequoia and Kings Canyon NPS' version of GIS.) Dave Graber, NPS Research Scientist who authored the latter article, describes the state-of-the-(GIS)-art at the parks and how additional information from many different investigators will revolutionize monitoring, caring for, and understanding "the incredible landscape preserved here."

To be put on the mailing list for **Sequoia Bark**, write Malinee Crapsey, Editor; Sequoia and Kings Canyon, Ash Mountain Box 10, Three Rivers, CA 93271.

* * *

Alaska Region

Dave Stevens has been assigned Branch Chief of Research in the Regional Office. He came to the Region from Rocky Mountain NP, where he led the research program from 1968. He will supervise the 3 scientists assigned to the Regional Office, administer the natural science program, technically advise park-based scientists and coordinate research in all the Alaska NPs.

* * *

Bruce Dale has been selected to fill the Region's new permanent Wildlife Biologist position. Dale has worked as a temporary for many years, assisting with much of the wolf and caribou research in the Region. He recently completed a study of winter wolf predation in Gates of the Arctic NP. In addition to continued involvement with Regional research programs, Dale will be primary contact for such wildlife management issues as the state of Alaska's wolf management planning effort.

* * *

Brad Shults, who has worked for the Region as a temporary Wildlife Biologist since 1987, accepted a permanent position with Northwest Alaska Areas in Kotzebue. Shults has assisted with much of the wolf and caribou research and recently has been conducting a study of marten demography in Yukon-Charley Rivers National Preserve as part of a Master's degree program at U/AK-Fairbanks. He will continue to oversee marten research to completion in 1994, while taking on new duties as the Wildlife Biologist fot the 4 northwest Alaska NPS areas managed out of the Kotzebue office.

* * *

The Regional Office welcomes Mark Schroeder, formerly Chief of Resource Management at Glacier Bay NP and Preserve, to the Natural Resources and Science Division. Schroeder will coordinate a variety of field projects throughout the Region, focusing primarily on neotropical migrants, coastal resource/marine mammal, and external threats issues.

Information Crossfile

A National Research Council report, "Protecting Visibility in National Parks and Wilderness Areas," found widespread air pollution across the country drastically diminishing visibility in even some of the most remote parklands. The report, cited in the Feb. 6, 1993 issue of *Science News*, calls current efforts to improve visibility inadequate, and in some cases "doomed to failure."

In the Western states, researchers found that people can see only half to two-thirds of the 230 km range that would be possible without pollution. In the east, average visibility is only one-fifth the natural range of 150 km. The vista-diminishing pollution comes from coal-burning power plants, diesel- and gasoline-fueled vehicles, residential and forest fires, and even livestock farms, the report states. It faults the EPA, Agriculture, and Interior for being slow to carry out responsibilities for accomplishing the goal of reducing haze in large national parks and wilderness areas, mandated by Congress in 1977.

"In particular," the *Science News* item notes, "it (the report) faults current efforts to improve visibility by targeting just individual polluters, a tactic the National Park Service used in a recent case involving a coal-burning power plant near Grand Canyon NP. The report calls instead for strategies that consider the various sources in a region that contribute to the haze."

* * *

A "miracle grass," called vetiver--native to India--was given the nod by the National Research Council in an NRC report released in late January 1993 and reported in the February 6 issue of *Science News*. A tall stiff grass that grows into a dense hedge when planted in lines along the contours of slopes, vetiver can slow runoff and prevent soil from washing off slopes, the report said.

For centuries, vetiver's roots have provided an oil used to scent perfumes and soaps. It is grown in 70 countries, but few use it for erosion control. Worldwide, 20 billion tons of soil disappear each year--the equivalent of about 6 million hectares of arable land. Vetiver's stiff stems and leaves and deep roots enable it to function as a virtual dam, even when dormant, and it survives for decades. Thus far, it has not spread or become a pest as have other plants, such as kudzu, introduced to stop erosion.

The report cautions that only domesticated vetiver from South India, which produces no seeds and spreads by vegetative propagation, should be used. The NRC report suggests that researchers evaluate whether this grass will prove useful as foliage along footpaths, railroads, and road cuts.

* * *

"What We've Learned About GIS: One Park's Experience" is the title of an article by Chuck Rafkind, Hugh Devine, John Karish, and Patti Dienna, that will appear in a future issue of the George Wright Society's **Forum**. The article was prepared as an answer to the dozens of questions received by Colonial National Historical Park with regard to the park's implementation of a park-based PC GIS. It summarizes both the positive and negative experiences of the park over the past three years in developing data themes under cooperative agreements with NC/State/U, the College of William and Mary, VI Institute of Marine Science, and the U.S. Soil Conservation Service. It also describes park development of GIS Standard Operating Procedures to guide development of new geographic and database files, database management, data dictionary, and cartographic map output.

* * *

"Through time and generations, certain patterns of thought and behavior have been accepted and developed into what can be termed a Western tradition of environmental thought and conservation," according to Arturo Gomez-Pompa and Andrea Kaus in their April 1992 **Bio-Science** article, "Taming the Wilderness Myth" (pp 271-9). But are these necessarily correct? "Scientific truth" is always subject to replacement by another "truth" in the light of new information that does not fit the old paradigm, say the authors, and they point to "equilibrium" and "climax" as two concepts that few ecologists defend today.

The concept of wilderness as "untouched" or "untamed" is seen as "mostly an urban perception," and the authors suggest that "we must learn how local inhabitants in rural areas understand their environment and must bring this vision into both the urban and rural classrooms." The fundamental challenge, they conclude, "is not to conserve the wilderness, but to tame the myth with an understanding that humans are not apart from nature."

* * *

In the April 3, 1992 issue of **Science**, three authors who are with the Finnish Forest Research Institute in Helsinki look at the biomass and carbon budget of European forests from 1971 to 1990 and conclude that while severely polluted areas (such as found locally in Montshegorsk in northwestern Russia) have suffered total tree death, moderate pollution may result in a general increase of forest resources. Their work points to fertilization effects that override the adverse effects "at least for the time being" in Austria, Finland, France, Germany, Sweden and Switzerland. "Biomass was built up in the 1970s and 1980s in European forests," they write. "If there has been similar development in other continents, biomass accumulation in nontropical forests can account for a large proportion of the estimated mismatch between sinks and sources of atmospheric carbon dioxide."

* * *

The upper forest canopy as viewed from an atmospheric perspective is the subject of a **BioScience** article (Vol. 42:9, pp 664-70) by Geoffrey Parker, Alan Smith and Kevin Hogan. This primary interface between the atmosphere and the forest is a reservoir of biological diversity and understanding of it is far from adequate, according to the authors.

"Access to the Upper Forest Canopy with a Large Tower Crane" is the title of the report, in which they describe observations made from the canopy as suggesting a wide diversity of functional behaviors of overstory leaves and a complex upper canopy structure. The large tower crane from which they made their observations, installed in a forest, allows repeatable sampling in three dimensions, unprecedented control for observations, and experimentation within the canopy space of the forest.

* * *

A surprising new database of the climatic history of the arid Southwest is described in the March 27, 1992 issue of **Science:** a stand of centuries old Douglas-fir trees recently discovered in the lava fields of El Malpais National Monument in western NM. One of these trees (dubbed "1062") is the oldest accurately dated living member of that species and is deemed by dendrochronologists to have sprouted 4 years before William the Conqueror invaded England in 1066.

The sites is protected both from fire and from competitors by the lava fields that surround it and may well spur dendrochronologists to search other lava flows--such as those in Oregon, Idaho, and California--for old trees. Ecologists will be encouraged to probe for the secrets of the trees' survival in what is for most plants a very hostile environment.

* * *

Restoration Ecology, "the first complete scientific journal for restoration ecologists," is a new, peer-reviewed quarterly journal, published for the Society for Ecological Restoration by Blackwell Scientific Publications, Inc. The journal will not distinguish between basic and applied research, and encourages all contributors to consider both the practical and the more fundamental implications of their work. The editors encourage submission of manuscripts that emphasize an holistic approach and that deal with the highest level of biological integration--the human ecosystem. The editor is William A. Niering, Botany Dept., Connecticut College, New London, CT 06320. To subscribe or request a sample issue, contact Blackwell Scientific Publications, Journal Fulfillment, 238 Main St., Cambridge, MA 02142

* * *

Jared Diamond, who teaches physiology at UCLA Medical School and practices conservation biology in Indonesian New Guinea, asks a tough question--"Must We Shoot Deer to Save Nature?"--in the August 1992 issue of **Natural History**. "Alas," he answers himself, "nature can't manage most nature reserves without our help." His article stems from "a magically beautiful, but painfully upsetting day in Fontenelle Forest near Omaha," where the author found nothing but mature oak, hickories and lindens. "I saw no seedlings," he writes...a sight that was "like visiting an apparently thriving country and suddenly realizing it was inhabited mainly by old people, and that most of the infants and children had died."

Fontenelle exemplifies the paradox underlying a bitter policy dispute; the paradox being that the twin goals of noninterference with nature and of preserving pristine natural habitats are incompatible. He considers the case of Yellowstone: whether to bring in wolves and outrage neighboring ranchers, or outrage the public by "culling" elk and bison. Diamond admits he is happy not to have to explain to the public why they can't pick flowers in a reserve where deer are shot. Managing for biodiversity is a goal with many problems left to be solved.

* * *

The entire matter of conflict of interest in science--especially with regard to reviewing articles in refereed journals--is considered in the July 31, 1992 issue of **Science**. The editor, Daniel E. Koshland, Jr., describes the policy improvements **Science** will use henceforth to "improve our previous procedures." He adds, "One of the problems of conflict of interest is the degree of sanctimoniousness attached to it.." Koshland vows to be "aware of intellectual as well as financial and social conflicts," and reports that **Science** is "adapting guidelines that have been used by the National Science Foundation over a number of years.

A special section addresses several facets of "conflict of interest," including the potential financial conflicts at the cutting-edge areas of biology (by Marcia Barinaga) and the much older and more pervasive form--"intellectual conflicts of interest" (by Eliot Marshall), in which a researcher's overriding investment in a particular hypothesis can lead either to boon or disaster.

* * *

A 91-page document, richly informative about the 500 years of environmental change since Columbus "discovered America" is available from its author, Richard L. Cunningham, Chief of Interpretation for the NPS Western Region. In *The Biological Impacts of 1942: Some Interpretive Thoughts*, Cunningham describes the native people of the West Indies, the decimation of the Indians, early biological impacts, a history of extinctions and endangered species, introduced animals and other organisms, biohistories of Haiti and Jamaica, threats to the Caribbean terrestrial and marine environments, and how all this "applies to my park," (with suggested topics, outlines, and slide show sources for developing your own park's program.)

In his Conclusions, Cunningham writes: "Columbus did not discover a 'New World'. Instead he found another old world with cultural and biological riches different from but as rich as those from the Europe he left. Columbus linked these two worlds into a common heritage that is still evolving. ... The continuing legacy of the Columbus event is not just historical, not just cultural, it is and will always be biological."

The Columbus paper, and another by Cunningham, *The Biological diversity of Food Plants: Some Interpretive Thoughts*, (52 pages), may be had by contacting Cunningham at NPS Western Regional headquarters, 600 Harrison St., Suite 600, San Francisco, CA 94107; (415)744-3910.

* * *

On Feb. 23, 1993, President Clinton announced the nomination of George T. Frampton, Jr., to serve as Asst. Sec. of the Interior for Fish and Wildlife and Parks. Frampton has been president of The Wilderness Society since 1986. Prior to that, Frampton was a partner in the Washington, D.C. law firm of Rogovin, Huge & Lenzner.

From 1973-75, he served as Assistant Special Prosecutor on the Watergate Special Prosecution Force and was a member of the team that conducted the grand jury investigation and trial of the Watergate Cover-Up case against President Nixon's chief aides.

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Figure 1. Dall sheep rutting habitat.

Dall Sheep Trophy Hunting in Alaska's Parks and Preserves: Biological Implications

By Francis J. Singer

The Alaska National Interest Lands Conservation Act (ANILCA) of 1980 designated 5 new parks and 5 new preserves that supported populations of Dall sheep, and added lands to a sixth, pre-existing park. As a result of this Act, about a quarter of the state's 70-75,000 Dall sheep were found within NPS boundaries. Subsistence hunting by local rural residents was permitted in the new areas and sport hunting was allowed in the preserves.

Congress mandated that wildlife populations in the parks be managed in a healthy and natural state, but Congress used these terms conceptually rather than definitively. Alaska continued to set seasons and bag limits, but with federal oversight to assure that the mandates were met. Concern was expressed that designation of the new parks, with their greater hunting restrictions, would focus greater hunting pressure on the remaining herds.

Dall sheep breed and spend the winter on open, windblown mountain slopes in Alaska (Fig. 1). Breeding takes place in early winter (mid-November through mid-December). Maintenance of adequate fat reserves following the stressful rut is essential to both males and females for survival through the remainder of the harsh, northern winter.

Lambs are born in mid-May. Inadequate fat reserves for ewes equate to lighter birth weight in lambs; smaller lambs survive at a lower rate. Timing of lambing also is critical. Early-born lambs can perish in late winter storms, while late-born lambs may not obtain sufficient body size and mass to survive their first winter.

During this study in 1981-85, the State of Alaska permitted limited, all-age subsistence hunting of Dall sheep in a few park areas, and unlimited hunting of 7/8-curl or larger rams in national preserves. The scientific community proposed several hypotheses concerning potential negative effects of sport hunting removals of only the oldest rams:

1. The social disruption hypothesis: Most breeding by males is restricted by dominance hierarchy to the largest-horned 7 year old or older rams. The older rams court ewes in a more ritualized, less hurried, less aggressive fashion (Fig. 2). When older rams are harvested, the younger rams may harrass ewes, thus wasting valuable energy reserves needed to survive northern winters.

2. The magnet effect of older rams on younger rams hypothesis: Rams will court ewes outside of the breeding season, and expend critical energy reserves; but rams typically segregate from ewes into separate habitats. This hypothesis states that older rams do not remain with ewe/young groups following the rut, and that younger rams will follow older rams rather than remaining with the ewes.

3. Immature ram incompetence hypothesis: Younger rams may breed ewes later or pregnancy rates may be lower than is the case with older rams.

4. Depressed survivorship in young rams hypothesis: Younger rams might die at a higher rate in hunted herds as a result of their increased role in breeding and depletion of critical energy reserves (Fig. 3). When older, more dominant rams are present, younger rams are excluded from most courtship and breeding activity.

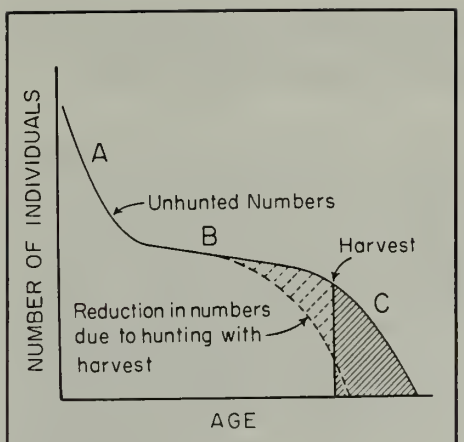

Figure 3. Generalized survivorship curve for Dall sheep rams. A: juvenile phase; B: immature phase; C: mature phase. If all mature rams are harvested, Geist's (1971) hypothesis predicts that the accelerated mortality associated with behavioral maturity (phase C) would be shifted to younger age classes.

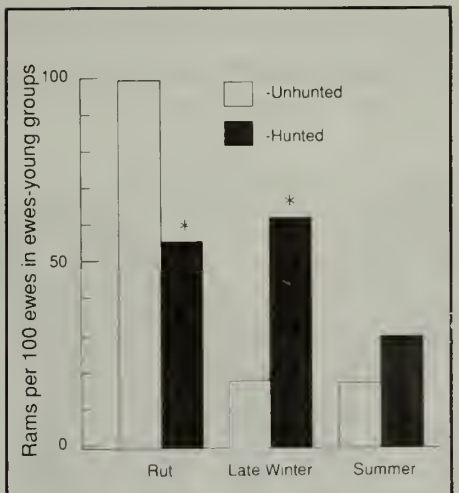

Figure 4. Young rams remained in ewe/young groups outside of the rut in late winger and summer significantly more in the hunted than in the unhunted herd, thus providing evidence for the magnet hypothesis.

Observations

Between 1981-85, with co-workers Ed Murphy (U/AK), Karen Laing (then of NPS), and Lyman Nichols (AK Dept. of Fish and Game), I studied demography, survivorship, and breeding behavior in hunted and unhunted Dall sheep herds in Alaska. Our studies were conducted in two areas that were not hunted--Denali NP and Alaska's Cooper Landing Closed Area. Each area had nearby area where all legal (7/8-curl or larger) rams were removed each season by hunters as soon as they reached legal horn size.

We observed that young rams harassed ewes slightly more than did older rams. Young rams performed twice as many butts, one-half as many twists (a ritual display), and chased ewes more than did older rams. Ewes were twice as likely to run away from an approaching young ram as from an older ram. However, actual energy expended by ewes, expressed as courtship time per hour of observation, was identical between hunted and unhunted herds, since (as a result of the ram harvest) proportionately fewer rams per ewe were present in the hunted herd.

We observed evidence for the magnet hypothesis; more young rams remained with the ewe/young groups throughout the winter in the hunted herds (Fig. 4).

No evidence was observed for immature ram incompetence. Lamb production and survival to yearling age were identical in hunted and unhunted herds. Lambing dates were nearly identical.

No evidence of depressed survivorship of younger rams was observed in hunted herds.

Conclusions

We concluded that under the 7/8-curl harvest regulation, Dall sheep populations in national preservesin Alaska met all the presumed criteria of a healthy population. Ewe energy expenditures, young ram mortality rates, and production of young were equivalent between hunted and unhunted populations. Some elements of natural selection, however, were missing from the hunted populations. There were fewer rams per ewe and thus less competition among rams for breeding opportunities. Ewes consistently accepted the courtship activities of the largest-horned rams in all groups, and this sexual selection likely had strong adaptive significance. For example, breeding with a dominant ram may increase the prospects of the lamb's also being a dominant individual with better survival chances. Removal of all the large-horned rams in a herd, therefore, may minimize male competition for mates and thereby influence natural selection.

Since completion of this study, the state of Alaska has raised the minimum size for harvest from 7/8- to full-curl in all the state except for the Brooks Range, thus further reducing concerns for the health of hunted Dall sheep populations in national preserves.

Singer is an NPS Research Ecologist, stationed at the Natural Resources Ecology Lab, Colorado State University, Fort Collins, CO 80523.

Figure 2. Dall Sheep in twist display toward adult ewe, Usibelli Mine study area, Alaska.

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Using GIS to Assess Potential Impacts Of Gypsy Moth Infestations at Great Smoky Mountains NP

By Hope R. Barrett and Stephen C. Nodvin

The gypsy moth (*Lymantria dispar*) (Fig. 1) is an insect pest whose larvae feed on tree foliage. Populations of gypsy moths often cause extensive defoliation of forests which sometimes results in tree mortality. Over the past 100 years, gypsy moth populations have spread south and westward from Massachusetts, the site of accidental release, and have produced one of the most serious forest pest management problems in United States history. By early next century, the expanding portion of North America that is infested with gypsy moth populations is expected to include the Great Smoky Mountains National Park (GRSM). The park, a 207,500 ha natural area on the border of North Carolina and Tennessee, serves as a center of biodiversity and is the most visited national park in the United States.

This study to assess the forests of GRSM for potential impacts from the inevitable moth invasion. A personal computer version of Earth Resources Data Analysis System (ERDAS) was the geographic information system (GIS) used to model forest defoliation and tree mortality events in the park. The three objectives of this study were to rate forests of GRSM for: 1) defoliation potential, 2) sensitivity to environmental stress, and 3) tree mortality potential. Evaluations of forest susceptibility, sensitivity, and vulnerability were completed during the rating process.

The term "susceptibility" refers to the potential that a forest will become defoliated given gypsy moth invasion. The assessment of susceptibility in GRSM forested areas was achieved using a three step modeling approach. The first step involved the development of a selection index. Forest types in the park were classified and mapped using satellite data and image processing (MacKenzie 1991). Forest types were then ranked for their likelihood of defoliation according to their tree species composition relative to species preference of gypsy moths (Table 1). Ranks were based on published studies of gypsy moth susceptibility in the northeastern United States.

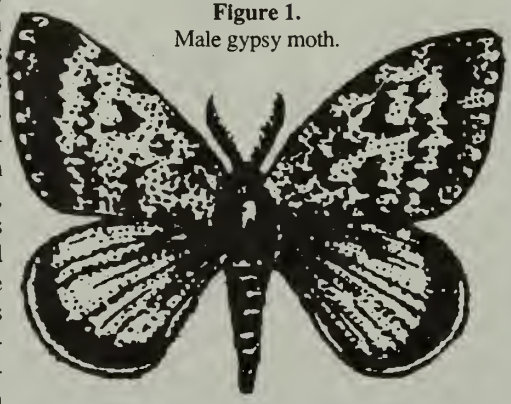

Figure 1.
Male gypsy moth.

The second step was initiated by delimiting sites in the park where gypsy moth introduction would be influenced by humans. These sites include: developed campgrounds, environmental education centers, visitor centers, picnic areas, and heavy or medium duty roads. A GIS was then used to delineate a zone around the sites which indicated expected gypsy moth expansion and defoliation within the first two years after their introduction into the park.

The third step involved using a GIS modeling program to ascertain susceptibility ratings for each forest type. Areas of susceptibility to defoliation within two years after gypsy moth introduction were delineated by finding forest types that were ranked for gypsy moth preference within the zone of gypsy moth expansion. The results of the susceptibility evaluation indicated that 64 percent of the park (131,972 ha) is projected to experience some tree defoliation within the first two years after gypsy moth introduction.

Forest sensitivity is the relative likelihood of tree death after forests are disturbed. It was assumed that forest types would be most sensitive to disturbances (*e.g.*, gypsy moth defoliation) at the extremes of their ranges along the topographic gradients of elevation, slope, and aspect. These three topographic variables were used to create map layers from a digital elevation model. Each map layer was cross tabulated with the nine forest types which generated frequency distributions of elevation, slope, and aspect for each forest type. The distributions were then evaluated for normality, and confidence intervals were located on each Gaussian distribution. Forest sites outside of the 95 percent confidence intervals of fitted Gaussian distributions were classified as sub-optimal. Forested areas of high, moderate, and low forest sensitivity to disturbance were identified by combining the sub-optimal sites of the elevation, slope, and aspect map layers (Table 2). A high sensitivity rating represented sites that were determined to be sub-optimal in all three map layers, while a moderate sensitivity rating represented sites that were sub-optimal in any pair of the three map layers, and a rating of low represents sub-optimal sites in a single map layer.

Vulnerability is the relative risk of forest mortality following defoliation. Vulnerability ratings of forest types were ascertained by finding every possible combination of susceptibility and sensitivity. The combinations were then assigned a descriptor that indicated a significance value (vulnerability rating) of high, moderate, or low. The results of the vulnerability evaluation indicated that 15 percent (30,416 ha) of the park is projected to be at some risk to stand mortality within two years after gypsy moth defoliation (Table 3).

Results from these evaluations are being provided to NPS staff to assist in development of management strategies prior to gypsy

Continued on page 27

Table 1
Gypsy moth preference ratings for forest types of the Great Smoky Mountains National Park

Preference	Forest Type
Highest	Mesic oak
High	Pine-Oak
High	Pine
High	Xeric Oak
Moderate	Northern Hardwood
Moderate	Cove Hardwood
Moderate	Spruce-Fir
Low	Mixed Mesic Hardwood
Lowest	Tulip Poplar

Table 2
Sensitivity ratings, and their hectares and percent composition of the Great Smoky Mountains National Park

Sensitivity Rating	Hectares	Percentage of GRSM
High	662	0.3
Moderate	8,852	4.3
Low	38,293	18 4
Total	47,807	23 0

Table 3
Hectares and land percentages of GRSM forests that are either high, moderate, or low in vulnerability to mortality within two years of gypsy moth introduction

Vulnerability Rating	Hectares	Percentage of GRSM
high	349	0.17
moderate	18,279	8 81
low	11,788	5 68
total	30,416	14 7

Moth continued from page 26

moth infestations. Strategies can be developed to protect against early infestations, and to focus protection efforts on those stands that are both vulnerable to mortality and considered critical natural resource areas. In addition, interpretive materials and programs can be developed from the results of this study to educate the public on the inevitable consequences of this exotic insect moving into the region and the efforts that the National Park Service will take to minimize the resulting damage.

Barrett is a Research Ecologist with the USFS at Morgantown, WV; Nodvin is with the NPS/CPSU at U/TN, Knoxville.

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Crater Lake Study Peer Review Panel Meets

A technical report on Crater Lake Limnological Investigations, mandated by the Congress in 1982, was presented Feb. 27, 1993 to a peer review panel at Oregon State University, chaired by Dr. Stanford L. Loeb of the University of Kansas Department of Systematics and Ecology.

The six panelists heard Principal Investigator Dr. Gary L. Larson review the program's goals and objectives and describe the lake's clarity, an integrated view of the lake's ecosystem, and the long-term monitoring program that is emerging. Dr. Robert Collier discussed lake circulation, hydrothermal processes, and particle flux; Dr. Peter Nelson presented the chemical solute mass balance picture; phytoplankton, zooplankton, and fish were discussed by Drs. C. David McIntire, Larson, and Mr. Mark Buktenica respectively.

Panelists' comments and critique will be presented within the next few weeks and incorporated as appropriate. The final report will be submitted to the NPS Washington Office by May 1993. In addition to Dr. Loeb, panel members are Dr. Raymond Herrmann, NPS, Fort Collins, CO; Dr. Hiram W. Li, USFWS, OR/State/U, Corvallis; Dr. Manuel Nathenson, USGS, Menlo Park, CA; Dr. Richard Peterson, Portland State U Biology Dept., Portland, OR; and Dr. John L. Stoddard, U.S. EPA Research Lab, Corvallis, OR.

Illegal Collection of Plants In Units of the National Park System

By Jenness Coffey

Fueled by the international market, the trade in medicinal plants has flourished over the last decade. According to a 1991 report by the World Wildlife Fund, (*Medicine from the Wild, an Overview of the U.S. Native Medicinal Plant Trade and Its Conserva-tion Implications,* by Douglas O. Fuller) some 600 medicinal herb species are commonly traded in the U.S. market, and a preference for wild-harvested over cultivated or artificially propagated plants has led to extensive collection from the wild. Incidents of illegal collection of plants in parks show that plants in the national parks are not immune to illegal collection for commercial gain.

Examples of the financial rewards for plant poachers include the following incidents:

- In the fall of 1990, organized groups illegally harvested mushrooms at Crater Lake NP. They were then air-shipped to Japan, where they sell for as much as $100 per pound.
- One of several illegal timbering operations inside New River Gorge National River in 1991 removed at least 10,500 board feet of hardwood timber with an estimated value of $6,000.
- Between Aug. 16 and Sept. 27, 1991, rangers made seven separate cases against poachers who were illegally taking ginseng from Great Smoky Mountains NP. The rangers recovered more than 800 roots that had been dug up illegally. Ginseng, valued in the oriental market as an aphrodisiac, sells in the U.S. for approximately $200 per pound and the price increases overseas.

A Native Plant Protection questionnaire was sent to the parks in 1992 to assess the extent and magnitude of illegal collection of native plants in units of the NP System. Since resource protection involves both law enforcement and natural resource aspects, the questionnaire was issued jointly by the Associate Director for Operations and the Associate Director for Natural Resources. Replies from 9 of the 10 NPS regions, showed that 99 species of native plants were known to have been illegally collected in 37 NPS units in 1990, and 88 species were poached in 41 NPS units in 1991.

Because plant collecting activities are driven by both the national and international markets, some species of plants are more intensively collected than others. The individual species reported by the most parks as being illegally taken was ginseng; seven parks reported such collections from inside park boundaries both in 1990 and 1991.

In addition to ginseng, other plants that were most often reported poached from parks in the eastern U.S. included the land's slipper orchid, rhododendron, iris, and jack-in-the-pulpit. In the Pacific northwest, various species of trees and ferns are taken illegally most often. In the southwest, yuccas and cacti top the list, with at least 13 different species of cacti being reported as illegally collected in parks in 1990 and 1991.

Replies to the Native Plant Protection questionnaire indicate that collection represents a threat to some species of native plants in NPS units. Acadia NP reported that plant poaching most likely has resulted in extirpation of *Cypripedium regtinae*, the showy lady's slipper orchid. Moores Creek National Battlefield reported that the Venus fly-trap, a plant popular in the wild plant trade, has virtually disappeared from the park, although the cause is unknown. And monitoring of *Zephyranthes atamasco*, the Atamasco or Easter lily, at Congaree Swamp National Monument has shown a decline in numbers. Like the Venus fly-trap, the Easter lily also is very popular in the wild plant trade.

Of the plants reported by the parks as being illegally collected, at least 20 are federally listed as endangered, threatened, candidate species, and/or are species protected by state law.

A survey of wildlife poaching in units of the National Park System conducted in the spring of 1991 showed 105 species of wildlife being poached in 153 parks in 1990. Although plant poaching is occurring in fewer parks than wildlife poaching, the number of species of native plants being poached is not significantly lower than the numbers for wildlife poaching in parks.

Coffey is a Natural Resource Specialist in the NPS Washington office, Planning and Information Branch, Division of Wildlife and Vegetation.

Genetic Diversity and Protection of Alpine Heather Communities in Mount Rainier National Park

By Regina M. Rochefort and David L. Peterson

The term biodiversity is frequently used to describe the number of taxa in a specific geographic location, however, it also refers to the genetic diversity of populations within a species. Genetic diversity is a basic component of all other levels of diversity (species, landscape, and process levels). It varies across space and time reflecting each species' life history traits and environmental and evolutionary history. Protection of genetic diversity is necessary for the long-term survival of species and populations because it provides them with the resources to respond to changing environmental conditions, regardless of the cause of that change.

Increased visitation in some parks may result in increased off-trail hiking and camping, potentially causing plant mortality and fragmentation of plant populations. These changes within populations may also decrease genetic diversity of a species, thereby reducing its potential for long-term survival. Resource protection guidelines such as Limits of Acceptable Change (LAC) may be strengthened by utilizing an integrated approach that combines demographic, life history, and genetic diversity characteristics of targeted species. We are currently conducting research on two heather species (*Phyllodoce empetriformes*, *P. glanduliflora*) to determine how genetic diversity data can be utilized to improve resource protection guidelines in Mount Rainier National Park.

Human Use Patterns

Each year almost two million people visit Mount Rainier NP. The most popular destinations are within the subalpine and alpine areas. Approximately 70 percent of all visitors go to at least one subalpine meadow (Paradise), and 98 percent of all cross-country camping (minimum impact camping without developed campsites) occurs within subalpine and alpine areas. This concentrates use on just 35 percent of the park's land mass and on the vegetation least resilient to human use. Overnight use in subalpine and alpine areas has increased by 43 percent since 1984 and is expected to continue to increase as urbanization encroaches on the park.

Resource Protection Guidelines

Mount Rainier NP encompasses 95,389 ha, of which 92 percent is designated Wilderness. Resource protection is addressed through overnight camping limits, LAC standards, and restoration projects. Maximum numbers of parties per night are designated for each crosscountry and alpine zone within the Wilderness. LAC standards for changes in landscape (vegetation) address the maximum number, size, and density of bareground areas, such as campsites, allowable within one wilderness zone. Restoration projects involve repair or protection of sites where noticeable damage has occurred following human use. Although these projects are usually initiated by development of at least one "severe" human impact (e.g. severe erosion or denudation), they usually address all impacts within an area. In this manner, restoration plans address areas of trampled vegetation and not just bareground sites (destroyed plant communities) addressed by LAC standards.

Mount Rainier's LAC standards currently focus on destroyed plant communities (bareground sites), which is the most severe form of damage from human use. Park staff now are trying to increase the accuracy of monitoring programs by improving methods for monitoring damaged plant populations. One method employs a qualitative assessment of plant health called "condition classes." Visual condition classes are a qualitative assessment of community "health." Condition classes are: 1) little change - no signs of human use; 1) definite change - some evidence of human use, broken or abraded plants, small bare areas, but minimal erosion; 3) severe change - uprooted plants, large denuded areas, severe, local erosion; and 4) habitat destroyed - all plants gone, extensive soil erosion. Recently, a survey documenting "condition classes" of plant cover, was conducted within the Muir Corridor alpine zone (approx. 16.8 ha). Each plant patch was mapped on an aerial photograph and assigned to one of the four visual condition classes. Although the zone meets LAC standards, survey results documented that 47 percent of the area shows definite change, 9 percent has been severely changed, and only 44 percent exhibits little change from human use (see photograph). Over half of the zone (56%) was damaged substantially and we are not certain how these levels of damage affect the potential for long-term survival of plant populations. We are studying the significance of different levels of human-caused damage on these plant communities and developing practical methods to monitor vegetation change.

Management of Genetic Resources

The USDA Forest Service (USFS) and Washington Department of Natural Resources (DNR) have identified conservation of genetic resources as a management objective. Specifically they use the concept of Genetic Resource Management Units (GRMU) to identify discrete components of genetic diversity within and between species populations. This concept is applied on a limited basis (Riggs, 1990) on some National Forests in California (Millar and Libby, 1991) and on many Washington DNR lands (Wilson, 1990). Each GRMU is composed of a core area and buffer zone. Size and location of GRMUs are based on:

(1) genetic diversity within a species population,

(2) reproductive and other life history traits, and

(3) species densities. Conservation plans for individual species include identification of several GRMUs.

The objective of GRMUs is to:

(1) conserve genes in an evolutionarily dynamic condition,

(2) maintain viable, genetically diverse populations of species, and

(3) provide control sites for monitoring (Millar and Libby, 1991).

They provide a tool for evaluating resource damage and developing LAC standards in Wilderness. Impacts from human use, air pollution, or other environmental stresses can be measured more effectively with GRMUs, because change can be detected more easily than at the population level in species or more complex levels of organization in ecosystems. In addition, they can be used to predict relative endangerment of species. Application of the GRMU concept is a recent development in biological conservation, and has been used as a management tool for only a few years.

Research Objectives

We are evaluating the concept of GRMUs as a management tool for protecting biological resources in Mount Rainier NP and its surrounding ecosystem, with an emphasis on genetic diversity of species populations (Rochefort and Peterson, 1991). This work is supported by funding from the Natural Resource Preservation Program. The research objectives for our study are:

(1) determine the genetic diversity of selected plant species in the subalpine/alpine zone of Mount Rainier NP,

(2) describe potential GRMUs for populations of these species, and

(3) develop resource management guidelines for application, management, and monitoring of GRMUs.

We are using a population genetics approach to address how the impacts of stress from urbanization and associated resource use can be identified in park ecosystems. We are specifically studying how these impacts affect the biological diversity of plant populations and how NPS resource managers can protect this diversity.

Research Methods

Our project utilizes basic genetic and ecological information in a framework that is directly applicable to resource management. Once data are collected and analyzed, management applications will be developed with a team of NPS and USFS resource managers and scientists. Our first step was to determine the geographic distribution and condition of two heather species: *Phyllodoce glanduliflora* and *P. empetriformes* populations. Heather communities are of particular concern due to their sensitivity to trampling, slow recovery rates, and length of time for community development. Specific heather communities within Mount Rainier NP have existed for as long as 10,000 years, although establishment of new meadows with continuous cover requires at least 200 years (Edwards, 1980). Populations were mapped on topographic maps and entered into the park GIS. Each population we monitor will be evaluated with regard to the severity of human impact using the park's visual condition class rating.

Currently we are working on the second step of our research-- surveying genetic and morphologic diversity of a subsample of populations of each species. Sample sites will be distributed at four general locations (north, south, east, and west sides of the mountain). At each of the four sites, paired populations will be sampled at the high and low elevation range of each species. At each population, 20-30 individuals will be sampled for genetic analysis and surveyed for several morphologic characteristics (needle color, angle, and size). Additional sample sites will be established within damaged populations in order to compare undamaged and damaged sites.

The third step will be to analyze genetic and morphologic variation with special emphasis on trends within and among populations and along geographic and elevation ranges. Genetic diversity will be determined using allozyme analysis (Allard, 1970; Asins and Carbonell, 1987). Allozymes are alternative forms of enzymes present as genetic traits on chromosomes, and provide standard yardsticks for making comparisons among populations and taxa. The greater the number of allozymes (that is, heterozygosity), the greater the genetic diversity of the organism. We also will determine if there are correlations between genetic diversity and morphologic and reproductive characteristics (Loveless and Hamrick, 1984).

Our final step will be to develop guidelines for the application of data on genetic diversity, demography, and life history to improve resource protection policies. Specifically, the GRMU concept will integrate NPS policies with scientific data as a means of protecting biological diversity within Wilderness.

Summary

NPS Service Management Policies direct us to protect biodiversity and state that we "... will strive to protect the full range of genetic types (genotypes) native to plant and animal populations in the parks by perpetuating natural evolutionary processes and minimizing human interference with evolving genetic diversity." (chapter 4:10). Policies also direct us to minimize our interference with gene pools during revegetation projects (chapter 4:9); however, there is little guidance available for resource personnel on how to apply this principle in the field.

Our study uses two high elevation heather species in Mount Rainier NP as a test case for how genetic diversity data can be integrated in the development of resource protection guidelines. This project will determine if quantifying genetic variation can provide additional protection to plant species beyond that contained in current regulations.

Heather community in Mount Rainier NP. This community is estimated to be 10,000 years old and been severely changed (condition class 3) by human use.

Rochefort is the Botanist at Mount Rainier NP and is currently on LWOP while working on her Ph.D. at the U/WA CPSU with Dr. Peterson. Peterson is Associate Professor and Research Biologist at the U/WA CPSU, Seattle.

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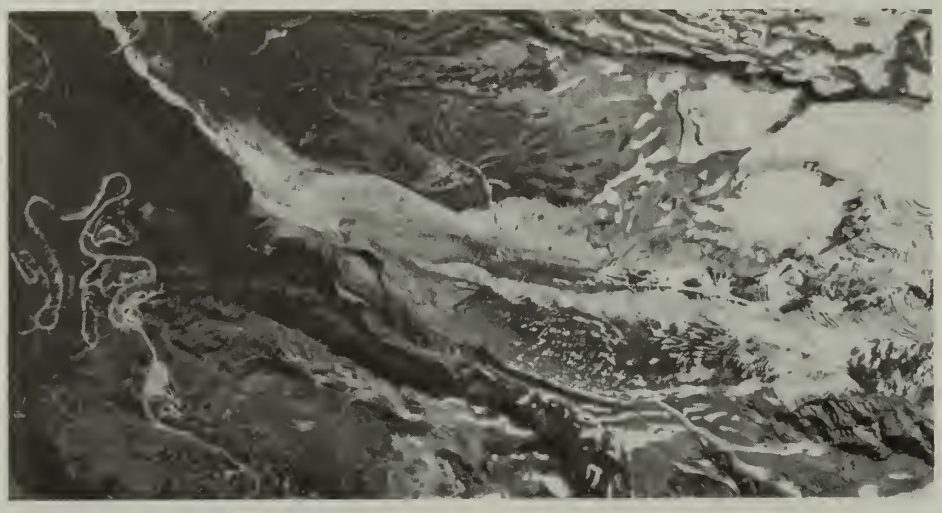
Nisqually Glacier Records a Century of Climate Change



Nisqually glacier on Mt. Rainier is shown at 1:24,000 in this NPS-contracted aerial photo. Paradise can be seen at lower right.

By Barbara A. Samora

There are 25 major glaciers on Mount Rainier and numerous unnamed snow or ice patches. The Emmons Glacier has the largest area (4.3 square miles) and Carbon Glacier has the lowest terminus altitude (3600') of all glaciers in the lower 48 states. The Nisqually has shown dramatic changes in dimension within the last century (Heliker, Johnson and Hodge 1983).

Global temperatures are increasing at a rate 10 times more rapid than the average rate of natural change. Climate change may be most quickly seen in glacier terminus fluctuations and changes in mass balance. Global warming may decrease the size of large glaciers and smaller glaciers may disappear.

Glaciers store information on temperature (Meier 1991, Raymond 1991) and past atmospheric composition (Lorius 1990). The estimated freshwater runoff from glaciers is significant--14 percent of the runoff in the conterminous states (Mayo and Trabant, 1986). Glaciers exert a significant control on the flow and water quality of park streams and rivers. Increased glacial runoff may have significant effects on flow, temperature, and sediment regimes in downstream areas. Reduced stream temperatures may eliminate or alter life cycles of certain invertebrate species.

The Nisqually Glacier on Mount Rainier has one of the longest and most complete records in the Western hemisphere of terminus position observations and ice-surface altitude measurements along specific profiles. A. Kautz first described the Nisqually Glacier in 1857. The USGS began research on park glaciers in 1896 when C. Russell recommended the glacier be studied and include photo stations, measurements indicating flow rates, and mapping of the glacier termini. In 1905, LeConte studied the flow rate of the Nisqually. Matthew of the USGS made the first accurate determination of glacier locations with his 1913 topographic map of the mountain.

Terminus position was recorded annually by the NPS beginning in 1918 and has been located using historical records, the earliest in 1857 as described by Kautz. In 1931, the Tacoma City Light Department and the USGS initiated measurements of surface elevation along profiles upon the lower Nisqually Glacier. They were concerned that the source of water for Alder Lake dam, the Nisqually Glacier, and every other glacier on Mount Rainier, was experiencing rapid retreat. Measurements were continued until 1985, when the USGS could no longer support the project.

In 1991, through partnerships with the Nisqually River Council, the Nisqually tribe, and with technical advice from the USGS, the park resumed monitoring of surface elevation profiles on the glacier.

The Nisqually has shown dramatic changes in dimension within the last century (Heliker, Johnson and Hodge 1983). Between 1857 and 1979 the glacier receded a total of 1,945 meters and advanced a total of 294 meters. Advances occurred from 1963-68 and from 1974-79. Ice surface altitude changes of as much as 25 meters occurred between 1944 and 1955. A significant thinning of the ice has occurred since the mid-1980s. The 1991 survey documented a loss of 22 meters of ice thickness from 1983 to 1991 in the lower profile; the middle profile showed a loss of 11 meters during the same period. The higher profile was not surveyed in 1991, but we would expect similar thinning of the ice to be occurring (Driedger, pers. comm.). The 1992 survey was conducted in late September and results are not yet available.

Implications of the more recent changes in the Nisqually glacier are that we will see additional cliffs and erosion at the margins, additional exposure of ice-covered moraine, and changes in runoff characteristics. Additional crevassing in areas such as the Muir Snowfield, the most popular route to ascend the mountain, is likely. More exposure of the ice-covered moraine would result in a greater source of unstable debris moving downstream in the event of an outburst flood or heavy precipitation. Subsequent changes in runoff characteristics may result in increased flow in summer and less in winter.

Mount Rainier's glaciers are important indicators of climatic change, major visitor interpretive objects, and sources of water for park aquatic systems, as well as hydroelectric and recreation pursuits outside the park. The volcanic-glacial interactions on Mount Rainier pose a major flood hazard to developed areas downstream extending almost to Puget Sound. Interpretation of wilderness features, wilderness travel safety, and glacier hazards are important management concerns. Greater understanding of past history and glacial processes is needed to address resource management needs of the park and surrounding communities.

Samora is a Resource Management Specialist at Mount Rainier NP.

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Resource Management Program Trains 117 in 10 Years

William H. Walker, Jr., Coordinator of the Natural Resource Management Trainee Program, reminds us that the program is currently in its 10th year of operation, with the 25 trainees of Class VI scheduled to finish their program in September 1993.

Of the five previous classes, 117 people have been graduated; of these, a remarkable total of 108 still are in the Service.

This year's graduating group and their current whereabouts are: Hubert Chakuchin, Denali NP, AK; Mike Tetreau, Kenai Fjords NP, AK; Elaine Furbish, Assateague Island NS, MD; Steve Rudd, Allegheny Portage Railroad NHS, PA; Pamela Benjamin, Pipestone NM, MN; Bob Daum, Indiana Dunes NL, IN; Charles Jacobi, Acadia NP, ME; Mary Starkey, Roosevelt-Vanderbilt NHS, NY; Susan Bloomfield, Great Falls Park, VA; Daniel Roddy, National Capital Parks-East, DC; Mark Buktenica, Crater Lake NP, OR; Leigh Smith, North Cascades NP, WA; Laurie Lee, Yellowstone NP, WY; Ralph Moore, Zion NP, UT; Thomas Ulrich, Grant-Kohrs Ranch NHS, MT; Jim Petterson, Virgin Islands NP, VI; George San Miguel, Big Cypress Nat'l Preserve, FL; Ted Waters, Chattahoochee River NRA, GA; Bill Fuchs, White Sands NM, NM; Cicely Muldoon, Buffalo NR, AR; Geoffrey Smith, Capulin Volcano NM, NM; Faelyn Jardine, Hawaii Volcanoes NP, HI; Chip Jenkins, Santa Monica Mountains NRA, CA; Michael Reynolds, Curecanti NRA, CO; Jonathan Paynter, WASO Natural Resources Office, DC.

MAB Notes

The **MAB International Coordinating Committee** (ICC) held its 12th session in Paris, Jan. 25-29, 1993. Representatives of 24 council member countries and 28 observer countries attended, including observers Mike Ruggiero, Chief of the NPS Wildlife and Vegetation Division, and Roger Soles, Executive Director of the U.S. MAB Secretariat. The ICC agreed on five priority theme areas for MAB:

- conservation and sustainable use of biodiversity
- exploring regional approaches to sustainable development
- communicating information on environment and development
- strengthening institutional capabilities to address problems of environment and development
- contributing to the global terrestrial observation system.

Biosphere reserves will play important roles in implementing these themes. The Council also recommended national reviews to strengthen biosphere reserve (BR) performance, integration of BRs into national biodiversity strategies, and emphasis on expanding databases on BRs.

EuroMAB expects to publish a directory in June 1993 that contains contacts and information on research programs and follows a slightly modified NPFauna format.

In 1992, UNESCO approved **additions to two US biosphere reserves.** Added to the Central California Coast BR are: Audubon Canyon Ranch (National Audubon Society), Bodega Bay Marine Laboratory (U/CA), Cordell Bank National Marine Sanctuary (NOAA), and Jasper Ridge Biological Preserve (Stanford U). The Central California Coast BR now has the largest number of units (14) of all U.S. BRs. Southern Appalachian BR additions are: Grandfather Mountain (private) and Mount Mitchell State Park (State of North Carolina).

Internationally, the **biosphere reserve network** now contains 311 units in 81 countries. These units represent 110 out of 193 terrestrial biogeographical provinces. The 47 U.S. units represent 13 out of 14 biomes in the U.S., 21 out of 25 terrestrial biogeographical provinces, and 9 out of 13 coastal/marine biogeographical provinces. Major gaps are the Colorado Plateau, Great Basin, Prairie Peninsula, Micronesia, Ozark Highlands, and the coastal/marine provinces Acadian-Boreal and Arctic Boreal.

In September 1992, **Northern Biosphere Reserve managers** from six Arctic countries--U.S., Denmark, Finland, Sweden, Russia, and Canada--met in Anchorage, AK to discuss possibilities for cooperation and communication among reserves. A subsequent preproposal developed by Marv Jensen, Superintendent of Glacier Bay NP, has now been approved by the U.S. MAB National Committee to go to final. The proposal includes developing computer databases on bibliography, research programs,and software/hardware capabilities, and developing an exchange program for northern BR managers.

All U.S. biosphere reserve managers should have received a letter regarding their interest in participating in a **MAB workshop** or series of workshops to finalize an action plan for U.S. biosphere reserves. Managers' interests and concerns will be used to develop a workshop agenda.

Napier Shelton, *NPS Wildlife and Vegetation Division, WASO*

Bill Gregg,*NPS MAB Coordinator, Washington Office*

Coral Colonies' Violent Chemical Warfare

The strange, silent world of the coral reefs, continuously engaged in internecine struggles, is currently the center of a scientific dispute between two schools of thought. One school holds that corals worldwide are seriously imperiled from global warming, overfishing, pollution, and reef destruction wrought by fishermen and tourists. The other holds that only a "case by case" study can describe what's actually transpiring worldwide on the coral front.

William K. Stevens of the New York Times News Service examined the evidence in a feature that appeared in papers nationwide in February 1993. He painted a grim picture of the violent reality underlying the seemingly dreamy tranquility of a healthy, normal coral reef –"colonies staging unrelenting chemical warfare on each other, their polyps stinging, dissolving and poisoning each other. Bigger reef creatures savage large chunks of colonies and fill the water with toxins."

But such competition–with no quarter asked or given–is the rule, he notes, in this interdependent but mutually hostile world. "When polyps in one colony come face to face with another in a constant competition for scarce space, they expand their bodies to engulf their rivals and exude digestive juices that turn the competitors to jelly."

Judith Land, a reef ecologist at U/TX's Memorial Museum, describes how polyps in the attacked colony grow "sweeper tentacles" studded with special stinging organelles that "zap the neighbors." Still other polyps enshroud their enemies in a sticky mucus that dissolves the tissues. Coral reefs, Stevens says "may be one of the most naturally poisonous environments on earth. On Australia's Great Barrier Reef, 73 percent of 429 species of exposed invertebrates were found to be toxic to fish.

Stevens quotes Drew Harvell, a coral reef ecologist at Cornell University, as seeing "tremendous potential" in these toxins as pharmaceuticals–as anti-inflammatory agents, as effective against AIDS, and even as anticancer drugs –"and that's just one class of organisms," Harvell said.

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Reorganization of the South Florida Research Center

By Michael Soukup and Robert F. Doren

Editor's Note: The following article was submitted prior to announcement of the proposed Biological Survey at the Department of the Interior. It is presented as an example of the kinds of research and management problems that have increasingly plagued resource management throughout the nation and that the proposed National Biological Survey is positioning itself to deal with.

Congress has not legislated clear direction for a scientific foundation for national park management (NAS 1992); hence the role of science in the NPS has never been clearly defined (Sellars 1991). Consequently, the Service has not developed the organizational, financial, and personnel requirements for a science program to match resource needs (Jarvis 1991). Perhaps the best example of recognition and substantial support of a park's science needs is the 1978 establishment, amid regional and park opposition, of the South Florida Research Center.

Everglades NP represents only the downstream fragment of the functional system it was intended to preserve. Since designation of Everglades NP, major flood control, water supply, and agricultural projects have continued to displace natural processes in the upper watershed; as a result, hydrological and biological systems in the park continue their decline.

Realistically, Everglades NP now is directly tied to a totally managed system. Much of the remaining Everglades ecosystem is managed by the South Florida Water Management District and the U.S. Army Corps of Engineers for flood control, water supply, support of agriculture, and protection of the Everglades. This circumstance leaves since 1.3 million acres of designated Wilderness dependent upon how these four objectives balance out before water is delivered through structures.

A Future in Doubt

Given this reality, the future of the Everglades is seriously in doubt. Perhaps the best one can hope for is a comprehensive management regime, which if skillfully crafted, will provide the vast expanses of Everglades NP with a water regime that mimics the original Everglades. However, even this–active restoration of the quantity, quality, timing, and distribution of water–requires a substantial and detailed system level understanding. And whether the park will now be managed for this kind of restoration, or only for visitor

Continued on page 4

The mangrove wilderness of Everglades National Park is a large labyrinth with irregular shaped islands.

PARK SCIENCE

NATIONAL PARK SERVICE

SUMMER 1993

A report to park managers of recent and on-going research in parks with emphasis on its implications for planning and management.

Editorial

In this issue, we focus on change.

Science in the National Park System and Service has been an evolving entity, shifting with the currents of the surrounding system within which it was embedded. There are two sayings that have pertinent currency within the General Systems Theory crowd: (1) a system self-designs, and (2) no system can understand itself.

These two rules of general systems theory help explain the position in which NPS scientific research, application, and interpretation find themselves today. The best of intentions, a host of well-educated, well-meaning personnel grappling with fragments of an ever-growing mountain of resource problems, led to a dawning recognition in the larger "system" surrounding the Park System that something different **had** to be done.

Beginning on page 1 of this issue, Michael Soukup and Robert Doren present an example of how informed resource specialists, in one of the National Park System's most threatened parks, have been attempting to solve the formidable problems of one park–a park that is inextricably linked with other parks in the region and with other management agencies.

Paired with this presentation is an article by Associate Director Gene Hester, describing what Stephen Jay Gould would probably call "punctuated equilibrium" in the evolution of science in the National Parks. In effect, the sudden shift from "park biology" to a National Biological Survey, as an approach to solving our growing biological resource dilemmas, is an indication of a system that was struggling valiantly to "understand itself" but that needed an outside look, and push, in order to make the evolutionary leap to the next level of self-design.

The new NBS will **not** completely understand itself, and it **will** self-design. But out of this larger, more inclusive approach to biological resource problems that no longer can be contained or solved within the National Park System alone, will come greater ability to "see" the problems, and better-armed ways of dealing with them.

Or so we all hope and pray!

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Dare to Save the Everglades

Editor's Note: The following piece is excerpted from an article by Nathaniel P. Reed, former assistant secretary of the Department of the Interior, veteran of 35 years working on Everglades problems, adviser to two Florida governors, and now a member of the South Florida Water Management District. It was carried in the Feb. 21, 1993 edition of the Miami Herald.

Last year–the year of great hope for the Everglades–may yet rank as the Year of Great Frustration, due to the gap between our grand promises and our minuscule accomplishments.

The National Park Service and the environmental community consistently rank Everglades NP as the most threatened of all our nation's parks. *The Miami Herald* has well reported the increasing sea-grass die-offs and algal blooms in Florida Bay. The visible problems have compounded quickly and the repercussions are now widespread.

That water is the heart of the problem is universally recognized. Water flows to the Everglades and Florida Bay have been dramatically modified by man. Water of the wrong quality now arrives at the wrong times and in the wrong amounts.

In 1992, with great fanfare, numerous agencies–the South Floirda Water Management District, the U.S. Army Corps of Engineers, the National Park Service–all made commitments to move forward aggressively with Everglades Park restoration efforts.

So what happened? The water management district, with great publicity, installed a temporary pump capable of moving an additional 100 cubic feet per second of water into the water-starved Taylor Slough and has proposed to "test" it for the next two years. This additional water is generally recognized by resource managers as wholly inadequate and a rather meaningless "test." The action also delays addressing the complex issues of delivering larger amounts of water while lessening potential adverse impacts upon competing users of the flood-control system.

In 1987, the water management district initiated a similar experimental two-year water delivery program from the Tamiami Trail gates into Everglades NP. Six years later, that "experiment" is just routinely extended with no effort to analyze the results and modify the program accordingly.

The NPS has been repeatedly asked to define the water needs of the park so that water managers can evaluate options to provide it. This critical work was again promised in 1992, but still remains uncompleted. The Corps of Engineers must stop stalling, stop equivocating, stop endless studying. The fate of the entire Everglades system–from the Kissimmee River Restoration, to Lake Okeechobee's mandated water-level schedules, to the water delivery systems to the Shark River and Taylor Slough–must be their "priority," not a difficult stepchild that needs another round of study and restudy.

The prevailing reasons given for government inaction are "the federal pollution lawsuit," insufficient funding, or Hurricane Andrew. The real reason is a lack of coordination, cooperation, and priorities.

Why haven't we accomplished anything significant? It's not lack of knowledge–we are indeed studying the Everglades to its death.

Perhaps the greatest problem is that the current bureaucratic process now effectively stifles government action. Restoration efforts have stalled for three reasons:

• **There is no agreement on what "restoration" means.** What level of recovery and/or protection are we trying to achieve in the Everglades? The goals range from meeting the needs of a single species to the undefined needs of "the ecosystem." There is no consensus regarding what parts we are trying to protect and what parts must also serve other public needs.

• **There is no clear game plan to get there.** Each agency is pursuing some part of the puzzle and frequently using the failure of a sister agency to move forward as an excuse to further delay its own efforts. We lack measurable milestones, deadlines, and responsibilities to move forward.

• **There is no leadership to ensure that all the important players work together with a sense of urgency.** There has clearly been no strong leadership or vision among the resource managers with responsibilities in the Everglades arena.

I believe it is well past time for a new approach–one built upon communication, cooperation, leadership, and "dare." It also is time to focus public attention squarely on the performance of the key players in achieving the goal they all profess to share.

As a first step, all the agencies need to form a high-level task team to define the restoration goal. I abhor forming yet another Everglades team, but the participants seem in such wide disarray that the only restarting point seems to be to lock them in one room and give them a collective shake! The team must have a fixed time frame–say, a short 45 days–to redefine the collective goals and define their respective obligations. The new secretary of the Interior, Bruce Babbitt, must intervene directly if necessary, to end longstanding conflicts between components of his agencies to produce a unified approach.

The new administration must also commit to promptly resolve conflicts between agencies such as Interior and the Corps of Engineers. Gov. Lawton Chiles must ensure that involved state agencies participate actively and constructively. The product must be a clear, concise plan for all agencies that the public can understand and track.

(In a discussion of "the Frog Pond" and "Rocky Glades," two properties within the historic eastern Everglades' watershed where competing interests have kept massive quantities of water from Taylor Slough and eventually from Florida Bay, Reed suggests that old conflicts must be settled and fundamental errors of public policy reversed.)

Florida Bay has too little patience left! We must take serious strides, not just shuffle our feet if we wish to save the Everglades/Florida Bay system. Bureaucrats too content to just step in place and deliver speeches at conventions should not be tolerated any longer. They should be held to standards of productivity and accountability.

The moment is opportune–we have informed, committed leadership in Gov. Chiles. The U.S. Department of the Interior, at last, has a knowledgeable, dedicated conservationist as secretary and the backing of an administration supportive of natural resource protection. I would challenge these resource managers to immediately define the key components of an effective plan for Everglades restoration. I would further challenge the Everglades Coalition to assertively and impartially chart their progress.

At presstime

June 14, 1993 – Interior Secretary Bruce Babbitt announced that NPS Associate Director Gene Hester has been assigned to a fulltime acting detail until October 1 as Special Assistant to the Assistant Secretary for Fish and Wildlife and Parks, heading up the effort to create the National Biological Survey. In the interim, Dennis Fenn is assuming Hester's duties, acting as Associate Director for Natural Resources.

use during further biological decline, will be decided as much (or more) *outside* its boundary as within... in technically-grounded political arenas.

Thus the NPS's hope for success in the Everglades depends on sound, proactive, technically-based programs, about which park managers can focus and rally the broad national and international public support that exists for the Everglades. With adequate technical power from its scientists closely linked with clear objectives and effective political skill from its managers, the portion of the Everglades that is the national park can be restored and preserved.

Need for Reorganization

The South Florida Research Center (SFRC), as Everglades NP's main source of technical support needs to be organized to support management efficiently as it grapples with these realities, and it must be supported at the funding level necessary to match the tasks at hand.

Currently the Center's base budget has remained essentially fixed since its inception, plus it has taken on nearly all the park's resource management responsibilities. To compensate, the Center has been forced to focus solely on Everglades NP (leaving Biscayne NP and Big Cypress National Preserve to develop their own programs). The Center's research effort has been weakened. The Center also has been forced to compete for "soft money," now bringing in over $2 million per year from other agencies for park-related research. However, dependency on such erratic funding does not allow a strong stable program. Thus we have looked for ways to become more efficient with our base funds.

Over the last two years, while immersed in such management realities as the Everglades Water Quality Lawsuit (among others), the SFRC staff engaged in many discussions on how to organize to respond better to park issues, accomplish a solid long-term research mission, and provide information in a more effective, timely way.

Subject-Oriented Approach Invalid

We concluded that the subject-oriented organizational approach in place since the Center's inception no longer provided appropriate working relationships or communication links. For example, the Hydrology, Wildlife, Vegetation, Marine Science, and Data Management programs did not work together because each was largely independent, somewhat redundant in staffing, and competitive. While each program was self sufficient (e.g. each carried out its own monitoring effort), none had any depth.

In preparing our presentation for the recent Targeted Parks Initiative for FY 92, it became clear to us that in order to tip the balance of the park's future toward restoration, the SFRC must succeed in four basic functions, which should be carried out by four **programs:**

1) inventory and monitoring (**I&M**);
2) Data storage, organization and access in a relational framework (**DATA MANAGEMENT**);
3) hypothesis testing, and the assembly of models (**RESEARCH**);
4) applications of science (**RESOURCE MANAGEMENT**) within the park and outside in the public decision-making arenas and processes.

Hence we decided to organize for these functions.

The **INVENTORY AND MONITORING PROGRAM** will provide data that drive hypothesis testing, model development, model verification, and trend assessment. With all monitoring under the I&M Program Manager, the present overlap in monitoring effort can be eliminated, with greater quality control as well. All components of the system will now be tracked and trends will be interpreted more frequently by the Program Manager.

Before, these activities were carried out in each topic-based program. The I&M Program now will undergo close evaluation as to priority, sampling protocols, and usefulness of the data by internal review. In each year's budget exercise, the monitoring program's effectiveness will be gauged by researchers for usefulness in model-building and testing, as well as by resource managers for identifying issues and tracking their resolution. Frequent analysis of monitoring data will inform managers of the results achieved by their decisions (either toward restoration or further resource impacts) in a much more timely fashion.

The **DATA MANAGEMENT PROGRAM** will receive all monitoring and inventory data and provide the relational framework (ORACLE-based), including spatial array (GIS), so the data can be used by scientists, resource managers, other agency managers and scientists. We have large volumes of data that never have been accessible and are, for all practical purposes, useless. Bringing these into the ORACLE relational framework will provide a return on this investment that will illustrate that data on the past Everglades–when accessible–are priceless. The beginnings of this process are well underway, and the work of our present Computer Division is our most exemplary internal communications effort to date.

The **RESEARCH PROGRAM** can field about 7 research scientists under the present level of funding. Presently we are very weak in modeling impacts of new threats as well as the effects of our own restoration proposals. Assembly of models from the relationships evident from monitoring and hypothesis-testing must be a cautious process. It is, however, the inevitable methodology for impact or restoration analysis in such a massive, complicated system.

Although two additional positions plus technicians, were requested under Targeted Parks funding, much of the future effort should be accomplished cooperatively with other agencies and universities, and through contracts. When sufficient funds become available, a large portion should be applied to balancing the in-house effort with work under cooperative agreements. This will allow maximum flexibility and reduce the isolation of our research scientists and staff. Each research scientist will provide up to 50 percent of his/her time directly to issues; such issues involvement will be tracked by the Program Manager of RESOURCE MANAGEMENT through Task Directives and timelines. The Research Director chooses task team members, monitors progress, products, and performance.

The **RESOURCE MANAGEMENT PROGRAM** will translate information into action. This Program will implement and direct resource management activities (exotics control, regional water supply planning, regional water quality issues, restoration implications for regional interests, recreational fisheries impacts and regulation, Endangered Species, Section 404 (USACOE) permit review, resource management planning, etc.) and coordinate Program activities with other SFRC Programs and park divisions.

Increased emphasis on plans and public awareness (with closer work with the Interpretation Division), and close direct linkage with the Research Program are priorities for the new Program. This Program will work directly with the Ranger Division, which will contribute on-the-ground implementation of resource management projects that are compatible with their needs to respond to many unscheduled events.

The need for coordination and logistical support for university researchers will continue and should grow. Likewise the need for editorial and archival support for publications, reports, and reprints will increase as our RGE positions and outside research ef-

forts expand. These functions are adequately covered in the current structure for the foreseeable future.

Research Director's Duties

The Research Director position will remain substantially encumbered as Technical Coordinator for the federal agencies while the Everglades Water Quality issues move from the federal courts to the State Administrative Hearing Process, or mediation. Additional duties also will fall to the Research Director's position as the NPS designee to the Technical Oversight Committee (TOC) established as part of the recent Settlement Agreement with the State of Florida. This Committee of technical representatives from five agencies will design all water quality monitoring and research programs in Loxahatchee National Wildlife Refuge, Everglades NP, and Water Conservation Areas 2 and 3, as required by the Settlement Agreement.

Extensive research programs to define numerically the state's Class III water quality standard, which protects the Everglades from nutrient induced imbalances in fauna and flora, also are required. The TOC will have responsibility to evaluate resource trends and certify compliance with water quality standards, at least until the year 2002–all of this in a public workshop format. Moreover, the TOC also has the unique opportunity to coordinate the federal and state research programs for all of South Florida, for the first time; a joint, cooperative approach would vastly improve the long-term chances of the Everglades.

Assistant Research Director Position Needed

The existing workload, added to the additional time required to address these other long-term issues, has developed into a need for an Assistant Research Director position. This position, redescribed from the former Wildlife Program manager position, directs all operations and support functions and assists the Research Director in setting policies and priorities for the SFRC.

Each new Program now depends to a significant degree on the successful performance of the others. Researchers support the I&M effort because their models depend on the right data collected correcly; the I&M personnel have a stake in working with the researchers to publish trend analyses and other characteristics of the system stemming from their data.

Everyone is dependent on the data management group to make the database accessible and useful. All the other groups rely on the Resource Management scientists to deal with issues at agency forums, etc., and the resource management group uses output from all three other groups, identifies research needs through the resource management plan update process, and provides feedback on how the combined efforts are doing in successfully addressing the main objective: supporting the Everglades ecosystem with timely and accurate information.

The new structure reflects the functional inter-relationships plus administrative support capability. The missing ingredient is simply enough base funding to fill our permanent positions.

There is strong internal support and enthusiasm for this change, and this year the process of inter-program presentations and budget critique worked well. As with any organizational structure, it will succeed or fail on the performance and cooperation of those involved. We hope this approach will contribute to the Center's effectiveness in determining the future of the Everglades.

Soukup, Director of the South Florida Research Center, is on detail for one year to the CPSU at Florida International University in Miami; Doren is Assistant Research Director of the SFRC.

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National Biological Survey: A Progress Report

By Eugene Hester
Associate Director for Natural Resources

Only a few months ago, the National Biological Survey (NBS) was only a concept and a commitment by Secretary Babbitt soon after his arrival as Interior Secretary. Much has happened in those few months and this new bureau is now a formal part of the Administration's FY 1994 budget proposal. It is scheduled to be a functioning new bureau by October 1.

I think of this proposal as entering its third phase. Phase one was a bold new concept, clearly and forcefully presented by the Secretary. He explained the need for a non-advocacy scientific biological sciences bureau and his vision for creating it. He reasoned that it could provide more and better data, understand the functioning of ecosystems, and enable managers to recognize ecosystems in trouble before the eleventh hour crises (ecological train wrecks) caused by the listing of endangered species and the attendant protective mechanisms required by the Endangered Species Act.

The second phase was the development of the FY 1994 budget by determining which parts of the nine existing Interior bureaus should be moved to the new bureau. This included FY 1993 base funding and new FY 1994 funds already proposed by each bureau. A task force of people drawn from several bureaus was given the responsibility. Basically, the research, inventory and monitoring, and information transfer capabilities within existing bureaus were closely examined for transfer, since these are to be the main responsibilities of the new National Biological Survey.

The evolution of this concept involved the development of a Science Council and a Policy Board. The Science Council will be made up of representatives from other Federal agencies, state agencies, professional societies and non governmental non-profit and research organizations. It will assist in improving coordination with entities outside of Interior and will offer suggestions about science trends and needs for the NBS.

The Policy Board will consist of senior representatives from all Interior bureaus. It will offer guidance to identify priorities for the NBS, so that it can produce data useful to resource managers.

We have now entered the third phase. This involves interaction with the existing bureaus as organizational units, not just task force members. It also involves interacting with Congress to approve the budget and with authorizing legislation which will be needed for a few specific items now in the Fish and Wildlife Service.

It also will involve development of specific mechanisms by which the objectives will be accomplished. Thse details will be necessary in order for people to understand organizational, supervisory, budgeting, and other aspects of how the work will get done. It will provide specifics to further develop the NBS from a concept to a functioning bureau by October 1, 1993.

Action vs. Rhetoric: Resource Management at the Crossroads

By Jonathan B. Jarvis

At the 1992 Ranger Rendezvous in Spokane, WA, I conducted two workshops titled "Action vs. Rhetoric: NPS Resource Management at the Crossroads" for a total of about 40 people. The intent of the sessions was to discuss and capture the attendees' feelings about the relationship between research, resource management, and park management, and to record recommendations for improving that relationship. This is a report from those workshops. I began each session with a talk that is summarized below. Following the summary is the input from those attending the workshops.

Presentation Summary

Now we have the final Vail Agenda to add to our bookshelf of reports on the "state" of the National Park System and Service. The Vail Agenda certainly is not the first such report, nor will it be the last; however it makes many excellent observations and recommendations. But what will it take to turn this rhetoric into action? Out there in the parks, on the front lines of resource conservation, protection, management, and understanding–how will this and other reports be converted into something that will truly make a difference in our jobs and in the future of park resources?

Picture yourself here:

You are the Superintendent of Big Mountains National Park, located in the wild west. You've got a solid staff, vast natural resources, a couple of horses for those frequent forays out to scenic backcountry cabins, a quality concessionaire, and a steady flow of happy campers. The sunsets are great, the air clean, and other than a meager budget, some rundown Mission 66 housing and a few personnel problems, everything is just the way you want it.

Monday morning: By noon the sh.. has hit the fan.

• A local county commissioner, objecting to your policy of protecting the natural flow of the Big River, has enlisted the Army Corps of Engineers to dredge and realign the river channel. They are to begin work on Friday.

• The State Fish and Game Department calls to let you know they are stocking all your naturally fish free lakes in direct opposition to your policy against exotic species. Stocking will commence Wednesday.

• The Senior Attorney for the Sierra Club Legal Defense Fund (SCLDF) calls to inform you they have filed a lawsuit in U.S. District Count on the grounds that your General Management Plan did not contain adequate data to analyze the impact of the decisions and development proposals.

• A seasonal maintenance worker has reported a thick, oily film on a wetland near the concessionaire's lodge. The film covers much of the marsh and has a petroleum smell.

• A seasonal patrol ranger caught a visitor family loading their car with over 200 pounds of wild mushrooms collected in the park. They are edible and the visitors state they are for personal consumption, however there is a strong local gourmet market for wild mushrooms.

• The local paper is running an article about a visitor who reported a near miss with a cougar on a park trail yesterday. The adult lion jumped into the trail within feet of their 5-year-old son, and was repelled only by the presence of their dog. That particular trail is closed to dogs. The visitor states he is going to call his congresswoman.

You call in your staff and find out that:

• You have virtually no baseline information on the Big River and only a smattering of water quality data. The district ranger knows there are bald eagles nesting along the river, but the resource management specialist says there are no monitoring data on the success of the nests.

• The backcountry ranger says they have good information on backcountry use, but nothing on the number of anglers. The resource management specialist says we have baseline data on only a few of the park lakes and she has no knowledge of research on the effects of fish stocking to fish free lakes.

• Your resource management specialist tells you that what SCLDF alleges is most likely true–that the planning team and the park didn't even have good maps of the area for the General Management Plan, much less any quantitative data.

• The chief of maintenance reports that over 1000 gallons of fuel oil are missing from the underground storage tanks at the concessionaire's lodge. The tanks are on a hillside overlooking the marshy wetland. The wetland below the fuel tanks is identified by the Fish and Wildlife Service in their wetland inventory but it is not mapped properly and there is no baseline on the vegetation found there. The chief of interpretation says several state-listed sensitive plants probably occur within the wetland.

• The chief ranger says this is the third incident this year with mushroom collecting for apparent commercial sale. The resource management specialist says the park has zero information on its fungi species.

• The chief ranger reports that mountain lion incidents have been on the increase in the park for the last three years and the past superintendent had been funding some cougar research out of park base, but you took the funding this year to build a new fee collection booth at the entrance.

Is this the time for Mylanta? Jose Cuervo? A look at the pink sheets? The only good news is that the rangers did not cite the visitor with the dog.

These are not made up; they are real life occurrences within NPS areas.

What are the connecting threads among these problems?

First: These are resource issues! Threatened river systems, alteration of naturally fish free lakes, impacts of development plans, wetlands and hazardous materials spills, resource exploitation, and wildlife encounters with visitors.

Second: They are crises with short and long term environmental consequences.

Third: There are no easy answers.

Fourth: Every one of them could go to court, or to the press, and likely will become very political.

Fifth: You have good **qualitative** information about the resources at risk, such as the local knowlege of the bald eagle nests, the sensitive plants, and the backcountry use; however, you have very little **quantitative** data on the resources at risk from these problems. While the qualitative information is valuable in recognizing a concern, it is the quantitative information you need in order to formulate a credible response to the situations in all their political, public relations, and legal implications.

Beyond all that, what is the best course of action for the resources themselves? How many mushrooms can be collected before there is an adverse impact on the fungi population; how do cougars respond to aversive conditioning and relocation, what resources have you lost in the wetland, and how will those lakes be affected when exotic fish are introduced?

Our defense of resources with only...gut feelings, apple pie and sunsets is increasingly difficult...

Superintendents are faced again and again with making decisions that may have long term detrimental consequences to resources, and we continue to make those decisions without reliable or adequate scientific information. We also are faced with protecting, conserving, and defending park resources that we cannot even quantify.

Our defense of those resources with only qualitative information, policies, gut feelings, apple pie and sunsets, is increasingly difficult in the legal arena, the court of public opinion, and the political process. And I am not sure it is the best we can do for the resources themselves.

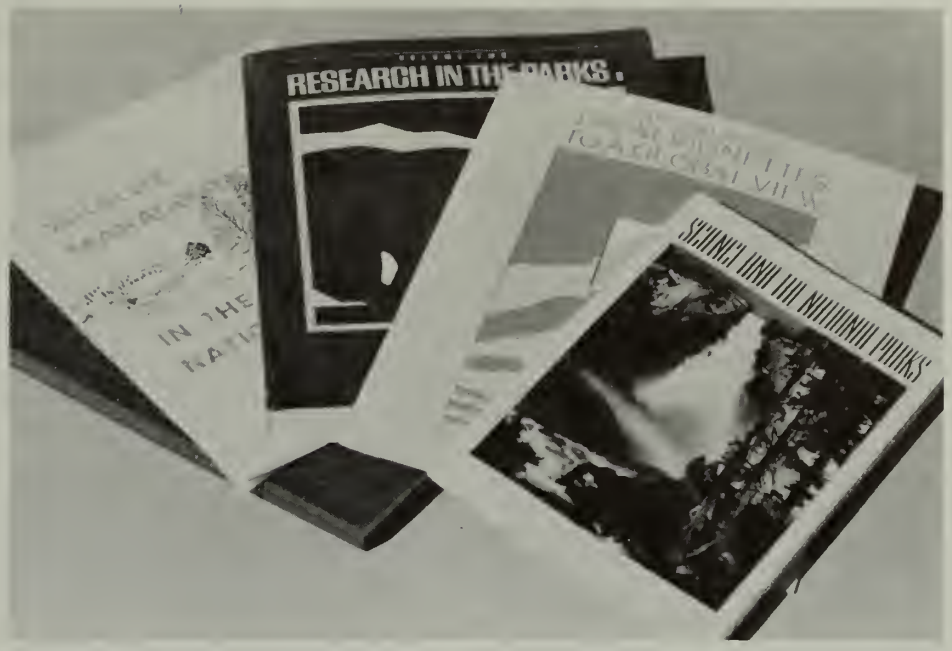
We need actions to convert the excellent qualitative sense of the resource felt by those working in the field into a quantitative information base that is useable and scientifically credible upon which to make management decisions.

To manage and protect the parks in today's arena, we need reliable, credible, understandable, relevant, and retrievable information about all the resources entrusted to us. The key to solid resource management is to convert the qualitative to quantitative through a solid research and monitoring program that is systematically interpreted for use by the park staff in educating the public, in decision making, in protection priorities, in planning and development, and in just plain understanding.

Fifteen years ago, in 1977, A. Starker Leopold and Durward Allen reviewed the NPS science program and made the following statement–still relevant today:

> *The National Park Service has reached a time in its history, and in the history of the nation, when science and research should be given a much greater and clearly recognized responsibility in policy making, planning, and operations. Seat of the pants guesses in resource preservation and management are open to challenge and do not stand up well in court or in the forum of public opinion.*

At least 12 reports since 1963 have dealt with NPS management of resources and the relationship between science and management. One of the first and most often quoted was the Leopold report, *Wildlife Management in the National Parks*, named for its chairman, A. Starker Leopold. The report recommended that modern scientifically based management techniques be applied and that park research programs be expanded. Since then, a succession of similar reports have come up with similar findings.



Also in 1963, the National Research Council made specific recommendations that the NPS strengthen research and have greater consultation between management and research units.

In 1979, the National Parks and Conservation Association Report, *No Park is an Island*, indicated that parks were indeed threatened, and this galvanized Congress into directing the NPS to survey itself. The result was the 1980 *State of the Parks Report*, one of the first self admissions of our lack of knowledge of the resources we were supposed to be protecting. The report stated that 75 percent of the reported threats were inadequately documented and that the natural science research personnel represented only 1.1 percent of the total NPS staff. The report recommended specifics for improving the NPS research and resource management program.

In 1987, the General Accounting Office (GAO) reviewed the NPS implementation of the recommendations from the *State of the Parks Report* and concluded: "The Park Service's strategy for better managing park resources has yet to be fully implemented."

In 1988, NPCA produced its magnum opus, the *National Park System Plan, Volume 2 on Research in the Parks: An Assessment of Needs*. It too made specific recommendations on increasing the role of science in park management.

In 1989, the Commission on Research and Resource Management Policy in the National Park System produced the so-called Gordon Report, *From Vignettes to a Global View*. This report, funded by the Mellon Foundation, recommended the NPS adopt a new vision, based on ecosystem management and sound research.

And now we have two more reports:

The Vail Agenda identified a variety of actions for NPS to take to revitalize the agency. Four Working Groups made some insightful and at times critical observations: "The NPS must engage in a sustained and integrated program of natural, cultural, and social science resource management and research aimed at acquiring and using the information needed to manage and protect park resources."

The most recent report, produced by the National Research Council of the National Academy of Sciences and titled *Science and the National Parks*, does an excellent job of recounting the numerous times the NPS has been told to get its research act together: "The recommendations of many serious reviews over nearly three decades reveal both a unanimity of opinion about the need for research to support resource management in the national parks and an abysmal lack of response by the NPS."

On page 9 of its report, the National Research Council observes: "However, the committee soon determined that the crucial problems in the NPS research program are not at the level of individual projects. Instead they are more fundamental, rooted in the **culture** of the NPS and in the structure and support it gives to research."

The fact that essentially the same set of recommendations has been made at least 12 times over the past 29 years with little concrete response lends credence to the allega-

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Interpreting Resource Management On a Self-Guiding Trail

By Dave Clark

Several years ago, our supply of trail folders for one of the self-guided trails at Craters of the Moon National Monument ran out. The brochure describing the cinder cones and lava flows of the area known as Devil's Orchard could easily have been reprinted. However, since the current guide was somewhat less than inspirational, we began to look for other ways to interpret this volcanic landscape. The decision was made to use this 1/2 mile trail to discuss resource management activities at Craters of the Moon. Changing the interpretive presentation proved to be quite a challenge. Presenting a series of resource management concepts in a logical manner while still relating the material to what the visitor saw at each stop seemed a daunting task.

Brainstorming sessions, however, soon suggested there were many different possibilities for developing site specific material. Features such as the broken surface of a lava flow were chosen as the focus of a discussion about visitor impacts on the volcanic features. Rocks heavily encrusted with lichens provided a site to present information on how air pollution was slowly invading the monument and destroying the cells of these plants. And finally, a grove of dead limber pine became the setting for a segment on how,in the 1960s, park managers cut down or chemically killed more than 5,000 trees infected with dwarf mistletoe. This was an attempt to prevent the development of grotesque growths known as witches' brooms, which managers of this time believed were "unsightly".

At other locations along the trail, the National Park Service's mission, the process of resource management, and the role visitor input plays also were discussed. At one location, the visitor is asked, "How would you keep people from walking off of the trails?" At the same time, they are provided with a variety of possible solutions that have been tried in other areas of the monument. The purpose of this exercise is to demonstrate the complexity of resource problems, the conflict between use and preservation, and the difficulty in finding solutions that work. All of this information will be displayed on a set of eight wayside exhibits funded with a grant from the National Park Foundation. In addition, the Craters of the Moon Natural History Association will be publishing a guide that provides more in-depth information about resource management issues. This guide will be different from most trail folders because it will not be used by visitors while they are walking the trail. Instead the guide will be provided at the end of the trail. In some ways, the success of our efforts will be measured by the number of visitors whose interest in resource management is piqued enough to want additional information.

Prior to the final development of this project, the monument's staff used a mock guide and set of waysides to test the visitor's reaction to our presentation. A focus group survey resulted in some interesting comments that revealed the following:

- Visitors are preconditioned to expect a traditional interpretive presentation on a "nature trail". Visitors are much more receptive when the reasons for a new approach are explained to them.
- A small group of visitors considered the presentation of this material the ultimate in "bureaucratic propaganda." Other visitors felt the interpretive message should be even more aggressive and hard hitting. The majority of visitors were very receptive to an interpretive presentation with a resource management theme.
- Parents had no problem with the material being presented at an adult level. They were willing, and in some cases delighted, to explain the information to their children. Many parents commented that this was a subject they particularly wanted their children to better understand.

Visitors pause to read about how park managers in the 1960s tried to stamp out as "unsightly" the grotesque growths of "witches broom" (dwarf mistletoe) that grew in the park. The efforts killed more than 5,000 trees, of which this dead limber pine and its com-panion growths are an example.

- When the area is a magnificent experience in itself, it is difficult to entice some visitors into interacting with displays or publications.
- Interpreters need to be extremely careful when working with concepts that are well-known to them, but less familiar to the visitor. Review by different readers and experts revealed that the information can be perceived in many different ways. Constant testing of the material and its presentation provided many surprises and improved our ability to communicate complicated ideas.

We know of several other self-guided trails in the National Parks that deal with specific resource issues (the recently built trail discussing the role of fire in Yellowstone is a good example). The trail at Devil's Orchard may be the first to attempt to define the entire process of resource management. During the summer of 1993, the production of a set of permanent wayside exhibits, the construction of a barrier free trail, and the publication of a guide titled, *Resource Management: The Science of Erasing Footprints*, will make our efforts to better interpret resource management a reality.

Clark is Chief of Interpretation at CRMO.

Interpretation IS Management

By Charles W. (Corky) Mayo
Chief of NPS Interpretation

The two articles included in this issue by Lois Winter and Dave Clark address an important concern regarding involvement of interpretation and interpreters in the NPS resource management story. If you believe that good information (facts) provide the building blocks of the interpretive story then it is a foregone conclusion that any and all involvement with those who collect and analyze the facts can only support our delivery of the park story.

Upon my recent arrival in Washington, I was pleased to hear from Bob Huggins that the Division of Interpretation is directly involved with several task force groups dealing with science and resource management. These groups include fire education, white-tail deer management, and natural resource education.

In the 80s, we bandied about the idea that interpretation is a tool of management. I would encourage you to read these two articles, for as they clearly point out, good interpretation is not a tool of management, but indeed management itself--with an equal and justifiable seat at the place of park decision-making.

Bridging the Communication Gap: Linking Interpreters, Resource Managers, and Researchers

By Lois Winter

Editor's Note: This is a slightly edited version of an article that appeared in the Fall 1991 issue of Interpretation--an issue that is no longer available.

In the Summer 1989 issue of *Interpretation*, Al Lovaas, Regional Chief Scientist in Alaska, stated: "If research can be thought of as the inquisitive and analytical mind of the National Park Service, interpretation is its heart." Parks desperately need scientists to document what resources we oversee and how we can protect those resources. But while scientific data is essential in courtrooms, and parks are invaluable control areas for researchers, parks are important for more than their scientific values.

I believe that in the minds of many visitors, the greatest value of parks resides in their inspirational qualities. But science is essential to interpretation, and to effectively inspire our sophisticated audience, interpreters need (among other things) current and accurate scientific information. Therefore, if we hope to protect park resources, researchers and resource managers need interpreters, and interpreters need researchers and resource managers.

Only when visitors understand the critical problems that threaten park resources can we expect them to play a role in minimizing those problems. Interpreters must use current research and resource management projects as tools to focus attention on resource issues confronting our parks.

In addition, interpreting research projects allows visitors to explore the value of parks as laboratories for social, cultural, and natural resource studies, an important park value that visitors may not intuitively appreciate. Furthermore, staying in touch with researchers helps interpreters remain current in their thinking and helps assure that information directed to the public is up to date. Finally, research and resource management are FUN to talk about! Effective interpreters are eager to enliven their presentations with new information, and visitors love to hear up to date reports describing what's going on behind the scenes to protect the parks.

Obviously, a communication link between researchers, resource managers, and interpreters benefits us all. But how successful are we at maintaining that link? Based on years of experience in interpretation, my two years in research, and discussions with tens of researchers and NPS employees, here are my recommendations for bridging the communication gap:

1. Designate a research liaison in the Interpretive Division of each park with the formalized duty of forging an effective link among resource managers, researchers, and interpreters. Many Park Service employees wax eloquent about the need for such communication, but a collective responsibility is one that tends to remain undone. By directing the responsibility to one individual it is far more likely that the job will get the attention it deserves. Duties could include any or all of the following:

a. Maintain good working relations with the park's resource management staff. Understand resource management's objectives, demonstrate familarity with the Resource Management Plan, stay abreast of current initiatives, attend resource management staff meetings, and suggest new research questions. Read scientific reports and journal articles relevant to park issues and attend science conferences. Occasionally observe and/or participate in field research projects.

b. Review draft research project proposals that define and formalize the NPS involvement with researchers. Carefully limit comments to the researcher-interpreter communications link.

c. When a new research project begins, attend meetings ordinarily scheduled between the park's resource management staff and the researchers. Cultivate a realistic understanding of the research project's objectives and limitations. Discuss ways that resource managers and researchers can assist interpreters to understand the research and interpret it to visitors... Assure researchers that their efforts to communicate with the research liaison will be evident in the park's interpretive program.

d. Throughout the project, remain in contact with resource managers to monitor progress. Researchers may be encouraged to lead a field trip, present a lecture, or write an update for field interpreters and/or park visitors.

e. At the end of the research project, maintain contact with the resource management specialist to confirm that all requirements in the research proposal with regard to the communications link have been met and final questions resolved.

f. Establish a network with nearby universities and state conservation agencies. Timely and important research directly relevant to park interpretation happens outside the parks' boundaries.

g. Digest, compile, and summarize research reports and other information from researchers and resource managers. Summaries can provide field interpreters a maximum amount of information in a minimum of time. Summaries can include a bibliography to direct interpreters to more detailed information sources. Encourage field interpreters to include relevant, accurate information on research in their programs.

h. Make sure a copy of every research report is accessioned in the park library. Deliver appropriate annotated research project slides and photographs to interpretive files.

i. Organize a lecture series on research and resource management projects relevant to the park for NPS staff, local residents, and visitors.

j. Design interpretive activities that highlight research or resource management projects. Invite visitors to participate in actual or simulated nesting surveys, gypsy moth trapping, air quality monitoring, beaver management activities, etc.

2. When drafting research project proposals, Regional Office Science Division employees should incorporate specific requirements to assure that park interpreters have access to important information from researchers. Ways of establishing the link might include:

a. Require that copies of the research proposal, thesis proposals, and final project reports and/or theses be delivered to the Interpretive Division's research liaison.

b. Require researchers to meet with the research liaison and resource managers at scheduled intervals until the project's conclusion.

c. At project conclusion, require the researcher to write a brief report in layman's language, summarizing research methods, results, remaining questions, and concerns that should be relayed to the public.

d. Researchers should be encouraged to make their required final oral report to the park staff at a time when a maximum number of "seasonals" are available to hear the presentation.

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Action vs. Rhetoric continued from page 7

tion that there is something about the NPS **culture** that is holding back the use of research in park management.

The NPS culture is exceptionally strong. The Association of National Park Rangers is evidence of that, as was the response by the NPS "family" to the tragedies of Hurricane Andrew at the Everglades. Our legacy of the committed, knowledgeable, field skilled, helpful ranger is as strong as ever. Our resistance to change and interference from hostile administrations is legendary. All of this is part of our culture and our strength. But we must look closely at our culture to determine if it also is part of a **problem** when one considers our slow response to the need for research and sound scientific data in making management decisions. As with the alcoholic, recognition that you have a problem puts you half way to recovery. My suggestion is that there are **cultural** barriers within the NPS that prevent research and resource information from playing a significant role in management decision making. Therefore, in order to make meaningful change, we should recognize those barriers and act positively to overcome them.

Workshop Responses

After the above presentation, I posed two questions to the group: **"What are the cultural barriers to the improvement of our understanding, conservation and protection of resources at the park level?"** and **"What are the actions needed to correct or overcome these barriers?"**

The response by participants was open and candid and offers insight into the question of organizational culture. The full response is available upon request, however the following is a summary. Concerning cultural barriers, some of the comments were:

- frequent transfers and lack of continuity
- lack of superintendents' understanding of research
- old school, scenery management
- crisis management
- rivalry and turf battles between resource management and rangers.
- rewards to superintendents for politics and facility development rather than research and resource management
- organization of resource management within the ranger division
- frequently changing "thrusts" in funding priorities

Based on the active participation by workshop attendees and their open and at times excited discussion, there are some strong ideas and feelings about "cultural" barriers that could be changed within the NPS to improve the relationship between management and science. Common threads I have identified from the above are:

- There is a need for training in resource management, monitoring, and research methods for everyone, but particularly for Superintendents.
- There is a need for accountability, again for all staff but particularly for Superintendents.
- There is a need for team building and reduction of rivalry between divisions through recognition that research and resource management enhance all jobs rather than competing with them.
- There is a strong need for funding continuity and the avoidance of seasonally changing "thrusts."
- There is the need to maintain continuity of research and resource management programs through staff changes, particularly at the Division Chief and Superintendent levels.
- There is a need to provide organizational consistency, with resource management as a division function in line authority to the Superintendent.

Many of the items above are within our individual control at the park or regional level. I believe, by recognizing the "cultural barriers" and taking actions to correct or alter them, we will make significant strides toward the long term protection, scientific understanding, and informed management of park resources.

Jarvis is Superintendent of Craters of the Moon National Monument.

Interpreters Note!

The following excerpts, from an article by Chris Maser, author of The Redesigned Forest, that appeared in the March 27 issue of the Corvallis Gazette-Times, provide material for illuminating the sometimes elusive subject of biodiversity.

"Biodiversity – the diversity of living species and their biological functions and processes – acts as an ecological insurance policy for the flexibility of future choice of management options. This is because every ecosystem adapts in some way to changes in its environment. In turn, the degree of a system's adaptability depends on the richness of its biodiversity, which provides a redundancy of function that retains the system's ability to respond to continual change.

"Redundancy – duplication or repetition of the elements of a system – provides alternative functional channels in case of a failure. Each ecosystem contains built-in redundancies that give it the resilience to resist change or to bounce back after disturbance...

"There is a point, however, at which the loss of one more species will tip the balance and cause the system to begin an irreversible change that may well signal a decline in quality and productivity. This point of irreversibility is an unknown biological threshold in that we don't know which species' extinction will trigger its effects. That's why it pays us to save every species we can.

Bridging the Gap continued from page 9

e. Require researchers to provide slides, specimens, or other tangible items that can be used in interpretive programs.

3. Because research may have significance in parks other than the one in which it was carried out, every Regional Chief of Interpretation should stay in touch with the Region's Chief Scientist. By maintaining a basic awareness of ongoing nationwide NPS research, the Interpretation Chief can alert each park's research liaison of potentially relevant research in other parks.

4. To emphasize its importance, incorporate a section in the Statement for Interpretation detailing interesting research results and describing progress and stumbling blocks in establishing and maintaining the interpreter-researcher connection. Establishment of the communication link among interpreters, researchers, and resource managers, possibly along the lines outlined above, will provide a vital tool for mobilizing public support for long term park protection.

Winter is presently Chief of Interpretation at Minute Man National Historical Park, P.O. Box 160, Concord, MA 01742.

USGS Provides Baselines For Two Alaska Parks

By J.G. Crock, R.C. Severson, and L.P. Gough

Through the cooperative efforts of the National Park Service, over the past two years U.S. Geological Survey (USGS) has worked in Alaska to develop geochemical and biogeochemical baselines for Denali NP and Preserve (DENA) and Wrangell-St. Elias NP and Preserve (WSEP).

Three fundamental objectives are common to all baseline studies, but first, a basic definition: A baseline represents the concentration of a given parameter measured at some point in time–a snapshot–and may not represent a natural concentration devoid of human influence.

Inherent in establishing baselines is the need to describe the nature and variation of the environment–important for attaching a confidence level to any geochemical map produced. Next is the need to assess the extent or intensity of alteration to the environment–how much has the system been disturbed (either naturally or by humans). Finally, we want to provide basic information for studying environmental processes–information for formulating hypotheses on the mobilization, transportation, and deposition of elements.

At DENA, in central Alaska, a coal-fired power plant in the town of Healy near the park's northeast corner may be enlarged from 25 to 75 MW. At WSEP, a proposed 10 MW coal-fired power plant near the town of Gakona would provide power for a proposed radar complex. At both sites our studies were to establish the feasibility of preparing geochemical and biogeochemical maps and to establish baseline information for native vegetation and soils. This information could then be used to assess possible geochemical impacts on the biological resources of the parks.

For these studies, we sampled *Hylocomium splendens* (feather moss), *Picea glauca* (white spruce), *Peltigera aphthosa* (soil lichen), and the top, organic-rich soil horizon. All samples were analyzed for their major, minor, and trace element content by a variety of analytical techniques by the Branch of Geochemistry staff.

Sampling sites for the DENA study were positioned at geometric intervals along three generally west to east traverses and one north to south traverse, all starting about 0.25 km from the existing power plant. The samples for the WSEP study consisted of three traverses originating from the proposed power plant site and going south and east into the park. Two different methods of baseline calculation were used. For DENA, baselines were calculated as a range of observed values from the samples collected at sites beyond 6 km from the existing power plant. This distance proved to be beyond the probable influence of the facility. For WSEP baselines were calculated from the total range of all samples collected.

Elemental concentration baselines for both areas followed the general trend of soil > moss > or = lichen > or = spruce. For most elements, there is good agreement with the limited available literature. For a given element, for a given medium, WSEP was similar to DENA. Noticeable point-source element concentration trends do exist for all the media sampled for the DENA study, but for many of the environmentally important elements there is a leveling-off effect seen 6 km and beyond from the existing power plant.

Crock, a Research Geochemist, Gough, and Severson, all are with the USGS, Branch of Geochemistry, in Denver, CO. Open-file reports on these two studies are available from Dr. Crock at USGS, Federal Center, Box 25046, MS 973, Denver, CO 80225.

Meetings of Interest

1993

Aug. 24-26 **12th WILLIAM T. PECORA REMOTE SENSING SYMPOSIUM**, "Land Information from Space-Based Systems," Sioux Falls, SD. Sponsored by the USGS in cooperation with other federal agencies. Contact: Dr. Robert Haas, Symposium chair, (605) 594-6007 or Dr. James W. Merchant, Program chair, (402) 472-7531.

Aug. 24-26 **CREATING A FORESTRY FOR THE 21st CENTURY:** A Landmark Symposium, Portland, OR, sponsored by the Olympic Natural Resources Center at Univ of Washington; to examine the state of knowledge with respect to forest systems and explore implications of that knowledge for management, planning, and policy. Plenary sessions, displays, demonstrations, discussions and field trips will culminate in production of a book. Contact: Kathy Kohn, U/WA, Coll. of For. Resources AR-10, Seattle, WA 98195; (206) 685-4724; (for registration information, (206) 543-0867).

Sept. 19-21 **ECOLOGICAL IMPLICATIONS OF FIRE IN GREATER YELLOWSTONE,** The Second Biennial Scientific Congerence on the Greater Yellowstone Ecosystem, at Mammoth Hot Springs Hotel, Yellowstone NP. Contact: Conference Registration, P.O. Box 117, Yellowstone NP, WY 82190.

Sept. 30-Oct. 2 **1st BIENNIAL ROCKY MOUNTAIN ANTHROPOLOGICAL CONFERENCE,** Jackson, WY, featuring a full-day symposium on "Mountainous Environments and Human Adaptation: The Greater Yellowstone Area," dealing with landscapes, fossil insect studies for understanding paleoenvironmental change, prehistoric settlement of the region, obsidian studies, rock art, geoarcheology and paleoecology of the uplands, and management issues in the mountains. Contact: Jamie Schoen, Bridger-Teton NF, P.O. Box 1888, Jackson, WY 83001 (307) 739-5523.

Oct. 25-28 **SECOND BIENNIAL CONFERENCE ON RESEARCH IN COLORADO PLATEAU NPs,** at Northern AZ University, Flagstaff; highlighting biological, cultural, social, and physical science research in NPs and related areas on the Plateau. Contact: Mark Sogge, CPSU/NAU, Box 5614, Northern Arizona U, Flagstaff, AZ 86001; (602) 523-9090.

1994

June 7-10 **FIFTH INTERNATIONAL SYMPOSIUM ON SOCIETY AND RESOURCE MANAGEMENT**, CO/State/U, Fort Collins, CO. Michael J. Manfredo, Program chair, has called for papers by Nov. 1, 1993, to Manfredo, Human Dimensions in Natural Resources Unit, CO/State/U, Fort Collins, CO 80523.

Wilderness Research Institute Named For Aldo Leopold

By Alan E. Watson

Aldo Leopold was an important participant in pioneering the concepts of ecological integrity and preserving wild places in America. Though the beginnings were modest, the current size of the National Wilderness Preservation System exceeds 95 million acres. The attention of federal land management agencies must now turn energetically to managing the values related to those areas.

Aldo Leopold and his creative management vision were honored recently, when the USFS Chief announced establishment of the Aldo Leopold Wilderness Research Institute in Missoula, MT.

The Institute's mission will be to obtain and provide information necessary to sustain wilderness resources in an ecologically and socially sound manner for present and future generations. This mission will be accomplished through research, publication, and training, using partnerships among agencies with wilderness responsibilities, non-governmental organizations, and universities.

Aldo Leopold, second from the right in this photo, posed with fellow foresters in this "Arizona foresters at work" photo taken July 25, 1910.

To reflect the research needs of the entire National Wilderness Preservation System, representatives from the USFS, the NPS, the USFWS, and the BLM will serve on the Institute's Steering Committee. This Committee will participate in defining short- and long-term work objectives for the research program supported by the Institute.

Currently it is anticipated that Institute scientists will lead research in five broad topic areas: (1) to protect the wilderness resource from both internal and external threats; (2) to facilitate provision of the beneficial uses of wilderness; (3) to allow comparison of relatively pristine wilderness with more intensively managed lands; (4) to understand global changes in resource conditions; and (5) to determine trends in use and condition of the System.

The core team of Institute scientists will come from the Forest Service's current wilderness management research project at the Intermountain Research Station in Missoula. These scientists will work with scientists around the world at universities or wilderness management agencies. The Institute will be located on campus at the University of Montana. Dedication of the Institute is scheduled for Aug. 21, 1993. Questions can be addressed to Director, Aldo Leopold Wilderness Research Institute, USDA Forest Service, Box 8089, Missoula, MT 59807.

Watson is a USFS Research Social Scientist at the Institute.

When Scientific and Cultural Values Meet

Editor's Note: This note on a trail ride accompanied Alan Watson's article on the Wilderness Research Institute; it deserves sharing.

It was early September, along the North Fork of the Sun River in western Montana. Daytime temperatures in the 60s contrasted wonderfully with the cold nights and early morning frost as we drew near the Continental Divide. Our group of six scientists and wilderness managers was on a 3-day, 75-mile packtrip into the Sun River Game Preserve portion of the 1.5 million acre Bob Marshall Wilderness Complex. Our purpose was to examine the effects of the 52,000 acre Gates Park Fire, on one of the less well-known, though substantial, wildland fires of 1988.

While our intent was to discuss vegetative changes and visitor reactions to the vast burned landscape, what remains in my memory is a strong symbolic image of wilderness. The skeletal remains of the forest presented a black and white landscape, punctuated by bursts of color from vigorous clumps of young aspen, from brilliant patches of crimson fireweed, from scattered lodgepole pine seedlings, and from the occasional bunch grasses of luminescent green. As we rode, Kelly, who grew up in nearby Choteau, mentioned he didn't see much of his young wife during the summer and fall months when he was a wilderness ranger in the highcountry of "the Bob." He said his other love, however, was always with him in this wilderness, especially in the burned over Gates Park area.

When we jokingly inquired as to this other love, Kelly dismounted, cut a thimbleberry stalk low to the ground, and went to work with his knife. As we watched, he hollowed out the pithy stem and made expert cuts at both ends of what looked like a green flute. He worked only a few minutes, then pressed the thimbleberry stalk to his lips and blew hard. The loose, stringy fibers vibrated in the tube as the air rushed through, creating a high pitched "bugle." An immediate bugle response came from a bull elk on high ground above the river bottom. It left no doubt in our minds that the identity of Kelly's "other love" was the feeling of belonging to this place.

With his demonstration of primitive skill in the middle of this vast burned laboratory, this young man reminded us of the many values wildlands offer. What I learned about human resourcefulness, the kinship between people and elk, and the symbolic interaction between humans and the land provided me with a lasting impression of wilderness that evades precise scientific description.

Service Reviews Effectiveness Of Resource Management Plans

By Steve Cinnamon, Adrienne Anderson, and Karen Rhem

A workshop on resource management plan (RMP) guidelines was held in Tucson, AZ, in early March to evaluate the existing process and guidelines and to make recommendations for their improvement. All Regions were represented by personnel who have responsibility for resource management planning activities.

Six parks, and staff representing all Regions, were involved in presentations and panel sessions on subjects including park programs, park, regional, and Washington office use of the RMP, role of RMP in planning and budget cycles, compliance concerns, and the software developed to capture Servicewide issues and needs.

It became apparent from the outset that not all Regions are using the plans effectively or in a consistent manner. The initial session on the history of RMPs indicated mediocre compliance with the 1981 guidelines. A review of the current status of the approved RMPs underlined the problem. It appeared to participants that for the most part the Service has not taken seriously the task of writing and following RMPs. As of December 1992, only 43 RMPs had been approved Servicewide. However, current information indicates that 220 Plans are in various stages of revision. The March 1989 guidelines held that all Plans were to be updated within the 4-year period.

Two key sessions were Mac Brock's (VOYA) presentation on how a park could use an RMP effectively, and Charles Van Riper III's step-down process, used to identify various program entities that need to be accomplished to achieve an end result. These two sessions demonstrated that resource problems are divided amongst various program area responsibilities; they were cited throughout the workshop as examples of how RMPs could be used effectively.

Central office support for RMPs is provided on the natural resource side by Jen Coffey in the WASO (Washington Office) Wildlife and Vegetation Division, and on the cultural resource side by Laura Feller in the WASO History Division. The WASO natural and cultural resource staffs are working together to support Regions and parks in RMP policy development and review. As awareness of resource management has increased, the importance of RMPs as the foundation on which resource management programs are built is being realized.

As regional representatives discussed tactics to implement the 1989 guidelines, it was apparent that the Southeast Region's approach to complete scoping sessions and to keep parks on a timetable has been effective. The scoping process, amended from that described by NEPA, has been applied with some success in six Regions. Regions that have not applied the scoping process, intend to try this approach.

The value of the RMP was discussed at a panel session with park, regional, and Washington office representatives. Some presented the RMP as a budget document, with brief narratives describing the problem and proposed action. These views were countered with perspectives that the Plans are keystone documents for the parks. The parks' resource management programs should be the heart of the Plans. The Plans serve several purposes: as an institutional memory; as a document reviewed by the public, researchers, and various agencies; and as a park program document reviewed by park management and fiscal managers.

The Plan has been project oriented with the problem statements reflecting how ecosystems are disrupted and how natural resource communities are jeopardized. Rather than brief narratives typically associated with budget documents, it was proposed that the Plan narratives be complete enough to describe why the resources are in the condition they are in; the narrative describing the park's strategy should be detailed enough to match the complexity of the resource issue. Current use of the RMP as a budget driven document competes with the view that the document should provide a programmatic approach to management of our resources. The various regional approaches to the use of 10-238s and outline of park planning requirements (OPRs) indicate that as a Service we are not on the same interstate highway. Instead, we are analogous to a number of frontage roads at various distances from the thoroughfare.

If the Service is to begin to consolidate the resource needs to meet its management objectives, focus should be realigned to emphasize the importance of the RMP as a tactical and strategic planning document. The Plan is used by a variety of people who have different data needs and interests. The Plan and project statements must serve as the institutional memory and be the environmental conscience driving park management.

Participants were reminded that the Plan is the central document that reflects the park's tactical and strategic plan for resource management. The project statements reflect problems facing our resources. The majority of the project statements on natural resources reflect "violations" of basic ecological principles. Habitats no longer are intact; populations are fragmented and unable to sustain themselves; air and water quality have deteriorated to the point that basic requirements for organisms or ecosystems to sustain themselves cannot be met. These conditions reinforce the observation that the park RMPs are rooted in conservation biology principles. As these principles are further violated, it will be more critical to look at management strategies to preserve the resources for future generations.

For cultural resource managers, the RMP Workshop was a thought provoking look at future management trends being developed for natural resources with an eye to applying them to management of the vast array of cultural resources in the National Park System. After extensive discussion, a consensus was reached that the R-MAP (Resource Management Assessment Program) process, developed by the Western Region (which develops sub-programs relating to resource needs), could provide programmatic direction for RMP development. The R-MAP staffing requirements relate to the personnel on hand and provide managers with a unique opportunity to visualize their staffing needs. While it is unclear whether WASO will develop a R-MAP program for cultural resources, there are several possibilities for expanding the use of integrated management techniques in addressing cultural and natural issues through the RMP process.

The Vail Agenda identified the need for natural and cultural resource management to work together in addressing the urgent needs and potential threats affecting the special places under our stewardship. The RMP can be the tool to implement a stewardship program based on the resources, rather than on personal preferences. Perhaps the most valuable insight gained was that there is common ground where natural and cultural resources can meet and provide a better future for all.

Walt Sydoriak (software contractor), Lincoln Fairchild (computer specialist, Cultural Resources), and Tim Goddard (computer specialist, Wildlife and Vegetation Division) presented a session on software development

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Insularity Problems in Rocky Mountain Bighorns

By Francis J. Singer

Most populations of bighorn sheep are small and isolated. Their populations in western U.S. are presently only a fraction (about 2-4%) of their estimated historic numbers. Most populations were extirpated in the late 1800s and early 1900s, due to overharvest (including extensive market hunting), habitat disturbances, and disease epidemics resulting from stressful contacts or transmissions from domestic livestock.

Eighteen of the NPS units (parks, monuments, and recreation areas) in the Rocky Mountain region historically supported bighorn populations. One of three subspecies inhabiting the region–the Badlands subspecies of the Dakotas and eastern Montana–was extirpated. Bighorns survived in only 5 of the 18 NPS units. Limited restoration efforts occurred over the past three decades until now some bighorns occupy 16 of the units. Many of the herds, however, occur in fragmented, isolated groups; 66 percent of the herds number fewer than 100 individuals. Five herds contain only 6-17 animals and are in immediate danger of extirpation (Fig. 1).

A few success stories exist. Bighorns survived the die-offs in Canyonlands and Rocky Mountain NPs and with some transplanting both parks are completely occupied by bighorn populations numbering about 1,000 each. Transplanted bighorns in Badlands NP tripled their numbers; they invaded the Stronghold unit on their own during the 1980s.

Insularity and Fragmentation

Life history and habitat requirements of bighorns in concert with human disturbances tend to predispose the species to fragmentation and small population sizes. Bighorns occupy patchy habitat, consisting of open cliffs and nearby grasslands. The animals avoid forested and low flat terrain and are poor dispersers. Knowledge of migration routes through such dangerous terrain is passed among generations; knowledge of the routes, lost with extirpated herds, may never be reestablished by transplanted groups.

Bighorn populations are hypersensitive to disease pathogens that wipe out some herds, further isolating any surviving groups. A dominance hierarchy among the males limits participation in breeding to only the oldest (7+ years), largest-horned, and most dominant males. Restriction of successful breeding to as few as 10-25 percent of the males reduces the effective genetic size of the group. Extreme inbreeding has been shown to result

in smaller horn size in bighorns, and in reduced dominance, fecundity, and fertility in many mammals.

Factors likely responsible for failure of past restoration efforts include

(1) too few transplants occurred and much occupiable habitat remains;

(2) transplanted groups are notoriously poor dispersers and typically remain on or near the release site;

(3) most transplant groups number fewer than 20, and if initial population growth is slow, inbreeding is likely;

(4) small, sedentary groups of bighorns are easy for predators to relocate, thus increasing the relative impact of predation, and

(5) transplanted bighorns may avoid historic habitats now overgrown with tall shrubs and trees due to fire suppression.

The Regional Initiative

Bighorn needs, assessments, and planning are underway in FYs 1991-93, with a WASO NRPP funded initiative. The program's goal is to restore bighorns to all occupiable habitat in the region. A first step was visitation to 15 of the units by scientific advisory committees. This process was completed in 1991.

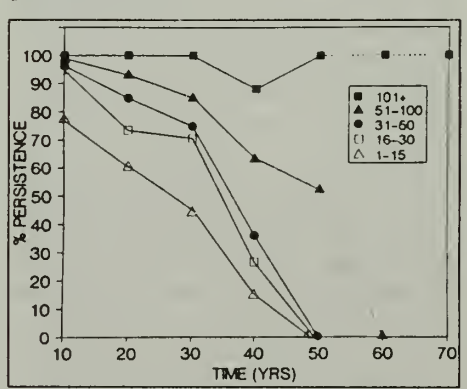

Figure 1. Persistence over time of bighorn populations of varying size (from Berger 1990). No population of less than 50 animals survived for 5 decades.

Secondly, GIS-based habitat assessments will be made of the suitability of potential transplant sites, to be accomplished by the end of FY 1993. Disease and genetic surveys will be conducted in all potential source herds for transplants and in any remaining resident groups.

A new census technique is being tested, the better to evaluate management programs. Experimental burning is being done in Badlands and Dinosaur in an attempt to enhance bighorn movements and recovery. Studies of the number of males participating in the rut and surveys of genetic heterozygosity will better define minimum viable population sizes. Interagency metapopulation restoration plans will then be drafted, source stock requested, any habitat improvements (e.g. prescribed burning) conducted, and then transplants and the follow-up monitoring conducted.

Ten interagency working groups have been convened. As a result of interagency cooperation, bighorn assessment expenditures on lands adjacent to NPS lands exceeds the original NRPP funding by a factor of 2.5 times. Most NPS areas are too small to support the entire metapopulation size necessary for long-term viability, thus cooperation with BLM, USFS, and various state agencies is essential. Restoration efforts are predicted to take another four years after the assessments and planning efforts are completed.

Two reports available from the author, at the NPS/CPSU, Natural Resources Ecology Lab, Colorado State University, Fort Collins, CO 80523, are:

Bighorn Sheep in the Rocky Mountain Region. Reports of Five Scientific Advisory Committees to the NPS. 39 pp. NPS, Natural Resource Publication Series, Denver, CO; and ***Problems of Insularity of Bighorn Sheep in the Rocky Mountain Region***; a review of current status and success of transplant efforts, NPS Natural Resources Technical Report Series, Denver, CO.

Singer is a Research Ecologist at the NPS/CPSU, CO/State U, Fort Collins.

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Bighorn die-offs due to diseases severely hamper restoration efforts. The largest recent die-off occurred in southeastern Utah in Canyonlands NP, Glen Canyon NRA, and adjoining BLM lands. The die-off started in or near the Needles district of Canyonlands in 1985, and by 1989 it had traveled nearly 100 linear miles through the North and then the South San Juan herds. Where once 1,000 desert bighorns roamed, fewer than 100 now exist. No evidence of recovery has yet been observed. Lamb survival still is essentially non-existent each year, and as recently as 1992, 3 of 5 adults captured in the Needles district were sick. Cause of this die-off has not yet been determined.

In 1992, WASO NPS selected the bighorn problem for Servicewide program development. Objectives are to (1) sample select herds for disease organisms, especially those with recent history of infectious diseases outbreak and/or chronic poor recruitment; (2) survey diseases in herds for potential transfer to avoid introduction of a novel pathogen, and (3) develop protocols as a model for other regions with wildlife disease problems.

From *Bighorn Diseases in the Rocky Mountain Region: a Servicewide Wildlife Disease Surveillance Program.* By Drs. of Veterinary Medicine Sharon Taylor, Mike Miller, Terry Spraker and Beth Williams.

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and the most recent versions thereof. The software has strength to meet many WASO or regional needs, yet does not lend itself well to park requirements for an attractive public document. The recent improvements include expanded reporting capabilities that will aid management inquiries and budget calls. Park people in attendance reminded the group that the software still needs betterment in order to meet their needs.

Workshop results emphasize improving existing guidelines and procedures. First, the software revision process will be bettered. A "software testing team" will review and test future versions of the software before they are released. A "software development team" will analyze feedback and set priorities for future software enhancements required by parks and Regions. A "technical support team" will be formulated to provide detailed software support for all users, via telephone or electronic mail.

Cinnamon represented the Midwest Region; Anderson, the Rocky Mountain Region, and Rhem, the Southeast Region.

Olympic Mountain Goat Update

By Paul Crawford

In the 1920s, 12 mountain goats were introduced into what would, in 1938, become Olympic National Park. By the 1980s, their population had grown to more than 1000 animals. Mountain goats, though a native North American mammal, are not native to the Olympic Peninsula; serious damage to the park ecosystem from their presence has been documented.

Park research on goats and their effects on native ecosystems has taken place from the 1970s to the present. Work has concentrated on impacts to soils and vegetation (including rare and threatened plants), biology of goats, sterilization/contraception as a population control, and live capture methods. Subject matter professionals from around the country have been consulted for advice and peer review in several aspects of the issue. A number of papers resulting from goat research have been published in refereed journals.

The park has written two prior NEPA documents: a 1981 environmental assessment on experimental management and a 1987 assessment on the first management plan. Many public meetings were conducted.

Between 1981 and 1989, 407 goats were live-captured, removed from the park, and released elsewhere in Washington and other western states. The live-capture program cost the park an average of approximately $1,000 per goat in 1989. In 1988, after 10 years of peer-reviewed research (including experimental live removals) and completion of the second assessment, the park began a goat management program that stipulated continued live-capture removals, with an option of shooting by park rangers to be considered in 1991. This program was terminated a year early, due to unacceptably high risk to park personnel and a rising mortality rate for goats during the capture operations. Practically speaking, the program had reached the limits of population reductions that could be achieved through live capture.

Current Status

In 1991 the Olympic National Forest (NF) and Washington State Department of Wildlife (WDW) joined with the park to form the Interagency Goat Management Team (IGMT). Within the park, NPS has sole management jurisdiction over all wildlife. On adjacent goat range in Olympic NF, the USFS manages the habitat, while the State manages the wildlife. The team's goal was to cooperate in writing a Draft Environmental Impact Statement (EIS) for mountain goat management on the entire Olympic Peninsula.

In January 1992, the IGMT sponsored a series of four scoping meetings, soliciting public comment on concerns and ideas that should be incorporated into a draft EIS. Alternatives for the park include no action, control (reduction) of sub-populations, and total elimination from the park.

At this date, problems have arisen with the differing agency mandates and policies, and although the State and Forest Service will continue to assist in the planning process, the EIS will apply only within the park.

Scientific issues related to the mountain goat program have undergone thorough academic scrutiny. The park's long-term study of goats and their effects on plants and soils was submitted for peer review last spring, was revised to reflect the reviewers' comments, and has been completed in final form. A peer review of sterilization and contraception techniques conducted in October 1991 determined that none of the techniques is feasible at this time. A thorough search of historical and archeological records has been conducted to answer any lingering doubts about the exotic status of the goats. The information from this records search also will undergo technical evaluation by subject matter experts.

Scrutiny in the print and broadcast media has been exhaustive, both locally and nationally, with recent articles in the *Wall Street Journal, National Geographic*, and *Reader's Digest*. There is strong and rapidly growing interest in this issue, with opposition being voiced by animal rights groups and strong support for goat elimination coming from conservation organizations.

Finally, the NPS Pacific Northwest Regional Office and the Washington Office have reviewed the research, policy, operational constraints, and law, and have accepted the park's analysis of the issue and recommended that it proceed with developing a DES. The matter is being viewed as a major test of NPS policies on exotic species management.

Crawford is a Resource Management Specialist at Olympic NP.

Turner River Restoration

Dump truck shown here is unloading fill material onto a canal plug. (*Photo by D. Weeks*)

By George L. San Miguel

The Turner River is a small meandering stream that emanates from the cypress swamps of southwestern Big Cypress National Preserve (BICY). The 9 mile long river empties into the Chokoloskee Bay estuary among the mangrove swamps of northwestern Everglades NP. The primary significance of the Turner River stems from the scarcity of such streams in south Florida. Its upper course is the only natural channel of fresh water available for recreational fishing and canoeing. At its south end, the Turner River Canoe Trail joins Everglades NP's 100 mile long Wilderness Waterway boat trail.

Prior to the 1960 construction of the Turner, Birdon, and Wagon Wheel roads, the river attracted tourists to Turner River Jungle Gardens, which offered boat trips along its course. After construction reduced the river's flow stages, small boat and fishing activities became limited to the dull, straight channel of Turner Canal. The canal was dug to provide elevating fill material for the road.

Construction of Turner Road and Turner Canal severed the Turner River from its upper drainage basin. Similar impacts were suggested for the Deep Lake Strand drainage in the northern part of the Turner Road and Canal construction area. Surface water, which normally contributed to the river's natural stages and discharges, bypassed the river, making much of the natural stream virtually unusable. River waters became shallow and stagnant. The stream bed began filling with detritus, promoting the growth of emergent thickets of giant cutgrass (*Zizaniopsis miliacea*) and cattail (*Typha domingensis*) and subsurface tangles of exotic hydrilla (*Hydrilla verticillata*), while surface waters became clogged with floating mats of water lettuce (*Pistia stratiotes*).

Congress authorized BICY in 1974. Peter Rosendahl and David Sikkema, hydrologists from Everglades NP, began field investigations in 1978 to determine the possible hydrologic consequences of restoring Turner River. Their 1981 final report became the driving force behind restoration efforts.

The excavation of Turner Canal and the filling of Turner Road resulted in several undesirable hydrological and biological consequences, affecting about 18,000 acres of wetlands. The area's canals lowered the groundwater table by up to a foot for about 600' on either side of the canals by draining groundwater during the dry season. Even such seemingly minor alterations in water tables can lead to major vegetation changes in a less wetland-oriented community and shift the local fire regime to a more flammable condition.

The area's canals shunt surface waters from north to south during the rainy season, thus raising southern area water levels and lowering northern area water levels during the summer and fall. Surface waters that naturally flowed into the Deep Lake Strand and Turner River were quickly diverted down the Turner Canal. The damming effect of the roads caused higher than natural stages to the east and lower than natural stages to the west. These new local conditions would lead to opposite long-term changes in vegetative communities and fire regimes on either side of the canal.

By cutting off much of the Turner River's water sources, the channel's depth was decreased. Shallower waters experienced higher temperatures, less dissolved oxygen, and different successional processes in and along the river. All of these consequences also influenced the river's aquatic fauna.

So little water was reaching the Turner River's channel that there was virtually no discharge from December through May and the otherwise diminished flow was measurable only 38 percent of the year. Reduced fresh water discharging into the river's distributary system would have a local effect of favoring salt tolerant species in an area where such had not been the case.

Diminished flows and lower velocities caused the otherwise suspended sediments to settle out of the water column and build up on the stream bed. In combination with changing water quality and quantity, the stream channel was colonized by plants atypical of the normally free river channel. As the river became choked with vegetation, flows began backing out of the river and into the canal during the high water season even after flow restoration was completed in 1989.

The hydrostatic head of fresh water flowing to the southwest normally prevents salt water from infiltrating much closer than a few miles from Tamiami Trail. After the construction of Turner Canal, the migrating wedge of salinity was able to reach the hydrological monitoring stations along this highway during the spring low water season. The stage recorder at the intersection of Tamiami Trail and Turner Canal even recorded a slight tidal effect! Water quality tests detected salt water at the station during about 12 percent of the days in a year, resulting in drastic changes in fish populations including periodic displacement or mass die-off of fresh water species.

All these effects tended to feed back on one another and worsen conditions. It was feared that the Turner River was dying and eventually would fill in and become shrouded by vegetation. The river's ability to serve as a recreational and natural resource in BICY and Everglades NP was in jeopardy.

The goal of the restoration project was to reverse the negative impacts caused by the Turner Road and Canal and allow natural processes to return conditions in the river to a state more closely resembling preconstruction. It was predicted that year-round discharge could be returned to the river with a measurable flow 88 percent of the year and about a 35 percent increase in the channel's depth.

From 1986 to 1989, a combination of federal, state, and county funds was used to modify the surface water flows that meet the Turner, Birdon, and Wagon Wheel roads

at Big Cypress Preserve

and their respective borrow ditch canals. Early estimates ranged up to $1 million as the price for restoration. The cooperative venture was able to keep the federal costs to about one quarter of this.

Each of these dirt roads is owned and maintained by Collier County. Little thought was given at the time of construction to the environmental repercussions of the design used. The priority in 1960 was to encourage homesteading, recreation, and commercial and industrial activities in this huge "worthless" swamp. In time, even the inadequate set of culverts that were emplaced were neglected and allowed to become clogged with debris and hidden by vegetation. As part of the restoration project, the county agreed to clear the old culverts.

The main component of the project was the installation of 21 canal plugs and 23 new culverts along 28 miles of county roads and canals. The work was performed in-house by the BICY maintenance staff. The plugs were designed to back up water flowing down the canals and build up the hydrostatic head behind these small earthen dams. The greater pressure provides the water with enough force to be flushed through the culverts that were installed behind the plugs. The culverts direct the water under the roads, where it then disperses back into sheet flow and finds natural channels such as Deep Lake Strand and Turner River.

The plugs were constructed of native limestone. Minerals then precipitated from the calcium-rich swamp waters into the pores of the plugs. This natural cementing process changed the loose fill into a concrete-like substance known as caliche, greatly increasing the impermeability of the structures. Vegetation was planted and large boulders were placed on top of the plugs to discourage off-road vehicles.

Numerous piles of rock were left over from the excavation of the canals. These artificial "uplands" and the filled road shoulders had been invaded by dense thickets of Brazilian pepper (*Schinus terebinthifolius*), an invasive exotic shrub. No one was able to see over or through the dense pepper hedges to view the natural Big Cypress landscape. BICY obtained $70,000 of wetlands violation fine funds from the Florida Department of Environmental Regulation, which paid for labor and heavy machinery to scrape the pepper hedges into piles for drying and burning. Debris left over from the burns, together with 800,000 cubic yards of spoil rock, were more or less evenly spread out and dumped back into the canals. The outcome was dramatic; these road segments are becoming the finest scenic and wildlife viewing drive in BICY.

The "Aquamog" clears vegetation from Turner River. (*Photo by T. Pernas*).

While flows improved in Turner River and subsided in the area's canals, the river channel remained clogged with aquatic vegetation. The river's obstructed condition limited the success of previous restoration efforts and severely inhibited its capacity as a recreational resource.

In 1992, the South Florida Water Management District volunteered the use of its "aquamog" and operator for several weeks. The aquamog was essentially a floating backhoe with interchangeable tool heads. It scooped up aquatic and emergent vegetation by the roots and chopped overhanging branches of encroaching woody vegetation. With the river's channel opened up to the mangrove fringe, the stream's greater velocity will keep the channel clear and halt or even reverse the sedimentation problem.

More urgent needs currently take priority, but quantitative hydrological analysis of the restoration project is likely in the near future. Some impediments to surface flow still exist in the Turner River area including small canals and abandoned roads. None of these structures has been mitigated, though they are on a long list of currently unfunded reclamation needs. An assessment also is needed of the effects that changing stages may be having on the various inhabited inholdings along Birdon Road and Turner Road.

There will continue to be dry season fish kills in the now stagnant canal waters. These fish kills are not considered to be a serious resource issue since the canal habitats are artificial, as are the fish populations that live in them. Additionally, as long as the terminus of Turner Canal remains unplugged it will continue to experience seasonal incursions of salt water.

Due to the persistent problem of exotic vegetation, there may need to be periodic retreatment of the area. Monitoring the condition of the plugs, culverts, water level, water quality, biota, and private properties will be an ongoing responsibility.

The Turner River restoration was the first project to be completed in the State of Florida's "Save Our Everglades Program." The project earned BICY's restoration crew a unit citation for excellence of service.

San Miguel is a Resource Management Trainee with the Resoure Management Division at Big Cypress National Preserve.

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Predation of Yellowstone Elk Calves

By Francis J. Singer, Kate K. Symonds, and Bill Berger

A 4-year elk calf mortality study on the Yellowstone northern range, undertaken to determine the causes and rates of mortality during the first year of elk life, has now been completed. Ever since adoption of the natural regulation policy in 1969, NPS has received considerable criticism for apparent lack of controls on the elk population. Douglas Houston, in his book on Yellowstone's elk, contended that the herd was regulated primarily by juvenile mortality in a density-dependent fashion; elk calves died at higher rates during winters when elk densities were high (based on drops in calf/cow ratios). Fall calf/cow ratios also are typically low in the population, suggesting significant mortality must also occur during summer.

Newly-born elk calves were captured each spring between 1987 and 1990 from horseback and helicopter. The calves were instrumented with motion-sensitive radio collars and released. Motion-sensitive collars double their signal pulse rate when no motion occurs for a specific period of time, indicating a likely mortality. When this occurred, field crews rode or skied into the backcountry and inspected the kill or carcass site.

More elk calves died during summer (32% of 127 marked calves) than winter (21% of marked calves). Nearly all mortality during summer was due to predation, whereas mortality in winter was primarily related to malnutrition. Almost all the winter deaths occurred during the severe winter of 1988-89, following the drought and fires of 1988. Winter elk calf mortality was relatively insignificant in the winters of 1989-90 and 1990-91, when elk numbers were reduced (supporting Houston's contention). Summer elk predation on calves, however, increased in 1989 and 1990 in spite of lower elk densities, in a density-independent fashion.

Heavier elk calves tended to survive better than lighter calves. Not surprisingly, more light calves were born following the drought and fires of 1988 and the severe winter of 1988-89. The scientific literature on many other ungulates such as red deer, caribou, and white-tailed deer also suggests progeny are lighter following severe winters or during periods of food shortage. Lighter weights at birth result in higher mortality from all causes. On Isle Royale, moose born to dams stressed by a severe winter are more vulnerable to predators throughout their lives.

Grizzly bears were one of the most significant predators on elk calves. Grizzlies killed about as many calves as coyotes and black bears combined. Based on our marking study and elk population estimates, grizzlies killed about 950 elk calves on the northern range each year. Wolf restoration has been proposed for Yellowstone Park. If summer predation on elk calves is density-independent (see double-outlined box), then wolf predation on elk calves would likely be additive to current predation levels, i.e. the total effect of predation likely will be greater following wolf recovery.

Our study discovered that summer predation on elk calves was far more significant than had previously been suspected. Our observations of winter mortality, although limited to 4 winters, tended to corroborate the contention of Houston that winter elk calf mortality was density-dependent and a potential regulatory force on the northern winter range.

Singer and Symonds are Research Ecologist and Wildlife Biologist, respectively, with the NPS; Berger is with Telonics, Inc.

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Motion-Sensitive Collars: A Technological Breakthrough

Motion-sensitive radio collars were first developed and used on wild neonatal ungulates in the late 1970s. The mechanism involved in their use is an interval timer, which doubles the pulse rate whenever the motion-free time equals that interval. For the Yellowstone study, the interval timer was set for 2 hours of inactivity.

The first collars often were clumsy packages whose useable life span was only a few weeks. Development of a sturdier package with a longer life span however, presented a trade-off with the potential of the collar to constrict the neck of a rapidly growing calf.

In 1989, the senior author initiated one of the first studies of neonatal caribou mortality in Denali NP, involving the use of the collars with a 1-year life span. The design used on Yellowstone elk calves is the culmination of advances in design. These collars are light, the material is elastic, 2 rip-out folds allow for rapid expansion, and a cotton section of the collar provides for deterioration and an eventual breakaway mechanism.

Yellowstone elk calves wore working collars for 1.5 to 2.0 years with no evidence of chafing or discomfort. At the end of that time, the collars deteriorated and dropped off. We compared survival rates of collared and un-marked calves (from calf/cow ratios) and found that radio-collared calf survival rates were higher, indicating that collaring of calves does not lower their probability of survival over that of un-marked calves.

Bears Found to be Significant Predators of Neonatal Ungulates Across North America

The advent of expandable, motion-sensitive radio-collar packages in the late 1970s and early 1980s resulted in discovery that both grizzly and black bears killed more neonatal ungulates than previously had been suspected. In 3 areas in Alaska and the Yukon, grizzlies killed 41%, 76%, and 84% of all marked moose calves, while black bears killed 57% in a fourth study. These areas are considered to have high predation levels. Wolves were present in all these areas, but in each case, bears killed more young calves than did wolves. In one of these areas near Tok, Alaska, grizzlies also chased down and killed more adult moose than did wolves.

The senior author worked in Denali NP in 1984 and 1985, when grizzlies also killed more neonatal calves than did wolves. (Wolves have since increased nearly 2-fold and they now kill more calves than do grizzlies according to Dave Mech and Lane Adams). Predators in Denali killed caribou calves at the more moderate rate of 46% (of 96 marked caribou calves) in 1984 and 1985, similar to Yellowstone's moderate rate of 32%. In more temperate northern Idaho, predators–mostly black bears–killed 65% of all marked elk calves.

French and French documented 3 major hunting strategies for grizzlies:

(1) The search, where the bear hunted sagebrush patches in a zig-zag fashion with nose to the ground. Elk calves were caught in this fashion even when no adult cows were present to suggest calves were in the area.

(2) The chase, when grizzlies charged groups of cows and calves and sought to separate and run down an individual calf. Grizzlies rarely caught straight-running calves, but cutting off the angle on calves running in an arc often proved successful.

(3) The ambush, when grizzlies charged out from the treeline at groups of elk in open sagebrush or meadows. Gunther and Renkin, grizzly bear researchers in the park, observed a high level of motivation by grizzlies to hunt calves; grizzlies chased elk in 26% of all May sightings and grizzlies chased elk for an average of 8.7 minutes. Forty-five percent of 130 chases observed by Gunter and Renkin and the Frenches resulted in capture of at least one elk calf.

Book Review

By Jean Matthews

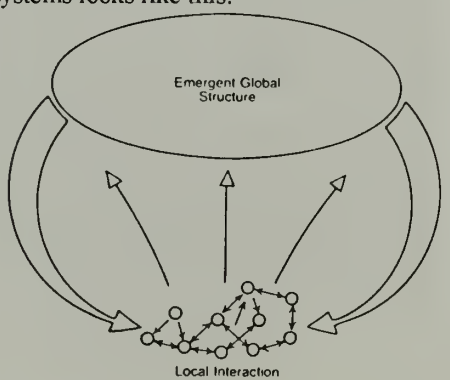
Complexity: Life at the Edge of Chaos, by Roger Lewin (Macmillan, 1992) is a spell-binding journey through the fields and laboratories of those who are pushing toward a set of rules that some day may provide a grand unification of the life sciences. Their various approaches to these elusive rules have landed them at the core of the current struggle to redefine evolution–or at least to rewrite the Darwinian version of it.

Lewin's story begins in Chaco Canyon, NM, the center almost a millenium ago of the complex, sophisticated Anasazi culture. Although it disappeared like steam from a boiling kettle, the Anasazis' economic, political, and religious web, which covered more than a hundred thousand square miles, is referred to by today's archeologists as the Chaco phenomenon.

From that bleak, arid terrain on the Colorado Plateau, the story moves to consideration of how such complex systems as the Anasazi culture might have arisen from a simple set of organizational rules. For someone who has read James Gleick's absorbing best-seller, *Chaos*, it may be hard to imagine a more enthralling journey through the frontiers of scientific discovery, but Lewin has provided a worthy sequel.

The theory of chaos is described early on in Lewin's book by Chris Langton of the Santa Fe Institute as a subset of complexity "in that you are dealing with nonlinear dynamical systems." In the case of chaos, he explains, a few things are interacting, producing tremendously divergent behavior–what he calls "deterministic chaos." It looks random, he says, but it's not, because it results from "often quite simple equations that you can specify." In the case of complexity, Langton continues, "interactions in a dynamical system give you an emergent global order, with a whole set of fascinating properties" leading to what the Complexity theorists call "emergence."

Langton's view of emergence in complex systems looks like this:



The interaction of the components at the bottom of the diagram give rise to properties that could not have been predicted from what you know of the component parts. And the emergent properties then feed back, to influence the behavior of the individual interactors that produced them.

Lewin then jumps back to the beginning of the story–in the early 1960s when a bright young scholar, Stuart Kauffman (now of the University of Pennsylvania) began playing around very seriously with random Boolean networks. Kauffman's ignorance of mathematics served him well; he accomplished something no knowledgable mathematician would have attempted. By incredible luck, early in his computer runs, his modest network stumbled into an emergence of order of a sort. His first thought was "Oh my God, I've found something profound," and he told Lewin "I still think so. It's the crystallization of order out of massively disordered systems. It's order for free." This "accident," born of intuition and nurtured by diligence and luck, is one of the first building blocks in an edifice that has arisen from similarly serendipitous starting points in a scientific landscape ranging from geology and biology to archeology and evolution. The names of contributors to this new scientific adventure include Murray Gell-Mann, Warren McCulloch, John Maynard Smith, Per Bok, James Lovelock, Stuart Pimm, Richard Dawkins, John Cowan, Edward O. Wilson, Stephen Jay Gould, and Brian Goodwin.

Lewin describes the debate between Gould and Goodwin as to whether complexity and the edge of chaos reveal a sort of progress in the random flow of Darwinian selection. When Goodwin is challenged about his definition of the idea of "quality" in an organism, he replies that by "quality" he means "the organism as the cause and effect of itself, its own intrinsic order and organization." Goodwin asks us to think of organisms as the result of a biological attractor–a sort of whirlpool in the sea of a complex dynamical system. Then, he says, "you begin to approach what I mean by quality."

In addition to the gripping story of how complexity theory has grown, by leaps of faith and intuition simultaneously in different disciplines and far flung geographic locations, I found most compelling the idea of Darwinian adaptation being only the surface manifestation of evolution, riding on the deeper structure of rules that seem to govern nonlinear dynamical systems of all kinds, throughout the universe.

The "emergenists" (as the seekers of these rules have been called) seem to have reached a tentative definition of "progress" in the evolution of systems: the ability to process more and more information. What should interest readers of *Park Science* is the possible role of this new theory as a push toward a holistic view of nature. The Santa Fe Institute people talk of "self-organization in complex systems, the emergence of patterns in evolutionary models that mimic patterns in nature, and the idea that living systems, as complex dynamical systems, are driven to these same patterns. They are saying there is a deep theory to the order of nature."

When they are accused of straying from mechanics and "looking for the meaning of life," they reply (in the words of Goodwin): "We're not looking for the meaning *of* life, more the meaning *in* life, the generation of order, the generation of pattern, the quality of the organism."

Kauffman adds: "Pure Darwinism leaves you without an explanation of the generation of biological form. In the Darwinian view, organisms are just cobbled-together products of random mutation and natural selection, mindlessly following adaptation first in one direction, then the other. I find that deeply unsatisfying and I don't think that's because I want there to be some purpose in evolution." Kauffman would reformulate Darwinian theory to include self-organization. "We have no theory in chemistry, physics, biology, or beyond, that marries self-organization and selection. To do so, as I think we must, brings a new view of life." In effect, he says, it extends self-organization from the realm of physics, where it's accepted, into biology, where it is still viewed as mystical at best and heretical at worst.

Lewin is a Ph.D. in biochemistry from the University of Liverpool. His most recent book, *Bones of Contention*, has been named the U.K.'s top science book for a general audience, besting both Stephen Hawking's *A Brief History of Time*, and James Gleick's *Chaos*. In May 1989, Lewin received the first Lewis Thomas Award for Excellence in Communicating Life Science.

From *Complexity*

"... if the concept of the edge of chaos does indeed translate from computer models to the real world, as Stu Kauffman, Chris Langton, and others firmly believe it will, then there will be nothing trivial about it at all. Stu's coevlutionary model systems get

Continued on page 22

Rocky Mountain Region

The Region's biannual Seienee and Resource Management conference, to be combined in 1993 with Interpretation's biannual Alliances conference, will be held Dec. 6-10 in Denver. The regionwide Alliances VI Conferenee will focus on improving coordination and information exehange among interpretation, resource management, and researeh. The conference will explore ways in which interpretation can better be utilized in resource management and ways interpretation can better ineorporate information from resouree management and researeh. Coordinators are Dave Dunatehik, Laura Joss, Bob Schiller, and Janet Wise (303) 969-2000.

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Planning has begun for the Fourth Conferenee on Fossil Resources, to be held in Colorado Springs in Fall 1994. The Fourth Conferenee will be sponsored by NPS and BLM. Florissant Fossil Beds NM and BLM's Canon City District Office will be hosts, in partnership with Friends of Florissant Fossil Beds and the Garden Park Paleontological Society. Assistance is needed in developing a program to address major issues affecting paleontological resources on public lands. Program development questionnaires have been mailed out. For a questionnaire or information on the conference, contact Dale Ditmason or Maggie Johnston at (719) 748-3253.

* * *

The Region has initiated an ethnographic researeh project in Bighorn Canyon NRA. with Dr. Larry Loendorf—an independent researcher in Tucson, AZ—heading the study in collaboration with the Crow Tribe. The study will identify areas and resources of cultural significance to the Crow and results will be used in environmental assessments. The Crow Tribe will also help determine ways to protect areas in the park used for traditional cultural purposes. The USFS has requested the NPS to expand the work scope to include study areas within the Custer NF. BLM and the State of Montana also have expressed interest in having the project address their land and resource management responsibilities.

* * *

Glen Canyon NRA is funding a survey for northern leopard frogs (*Rana pipiens*) along the Colorado River corridor from Glen Canyon Dam to Lees Ferry. The frog surveys will be coordinated and conducted by Charles Drost (Zoologist, CPSU/UC) and Mark Sogge (Ecologist, CPSU/NAU), and will document abundance, distribution, and habitat utilization.

* * *

The Colorado Plateau Vegetation Advisory Committee (CPVAC) in conjunetion with the NPS CPSU/NAU sponsored a field training session at Mesa Verde NP on June 16-17. Participants received hands-on instruetion in the use of the Brown, Lowe and Pase vegetation classification system. Anyone interested in what transpired at the session can contaet either Steve Budd-Jack (MEVE) at (303) 529-4510 or Elena Deshler (CPSU/NAU) at (602) 523-9090.

Southeast Region

SER Chief Scientist Dominic Dottavio has aecepted a position as the dean at Ohio State University in Marion. His extensive researeh record and administrative baekground were cited as factors in his selection. Dottavio, a native of Ohio, was the first ehoice of the selection committee after a year long search that attraeted 200 applicants. He begins his new work in August.

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A draft eoastal park inventory and monitoring handbook has been completed and distributed to eoastal parks from Acadia to Padre Island. The handbook contains draft protocols developed as a result of the I&M workshop held at U/VA in August 1992.

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The second annual Big Cypress Wildlife Research Colloquium was held Feb. 4, 1993, at the Oasis Visitor Center. Presentations were made by represcntatives from NPS, the U/FL, and the Florida Game and Fresh Water Fish Commission.

* * *

William Loftus, Research Ecologist at Everglades NP, began a collaborative projeet with Dr. Horton Hobbs of the U.S. National Museum to redescribe the Miami Cave Crayfish (*Procambarus milleri*), a subterranean species with very localized range. Life history information also will be presented for the first time.

* * *

U/GA CPSU Director Bob Warren travelled to Mexico at the invitation of the University of Veraeruz in Xalapa. He presented four seminars to faculty and graduate students, toured their Tropieal Rain Forest Park for Wild Plants and Animals, and met with administrators to discuss future joint researeh and graduate education efforts. University researchers and park administrators were interested in the bobcat reintroduction research Dr. Warren has directed on Cumberland Island National Seashore (NS), his researeh on raccoon ecology and sea turtles at Canaveral NS, and his researeh on white-tailed deer.

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Recently published reports inelude:

Van Cleave, R. 1993. ***Trail Use in the Cades Cove and Abrams Creek Area of Great Smoky Mountains NP.*** NPS/SERGRSM/NRTR 93/03.

Cole, A., and K. Turner (eds.). 1993. ***Barrier Island Ecology of the Mid-Atlantic Coast: A Symposium.*** NPS/SERCAHA/NRTR-93/04.

Artieles published:

Jodice, Patriek G.R. 1993. ***Movement patterns of translocated Big Cypress Fox squirrels (Sciurus niger avicennia).*** Florida Scientist 56(1):1-6.

North Atlantic Region

"Is eommercial shellfish harvesting compatible within an urban national wildlife refuge?" This question is the title of an article published in ***Fresenius Environmental Bulletin*** 2:174-178 (1993) Birkhauser Verlag, Basel/Switzerland, by John Tanacredi of Gateway NRA. Tanaeredi concludes that sueh shellfishing is incompatible with the wildlife protection mandates of the urban national park concept,and that such programs based solely on baeteriological monitoring are inappropriate.

Midwest Region

David Figlio, a PhD. candidate at U/WI-Madison, conducted a cost/benefit analysis of Pietured Rocks National Lakeshore (NL) as part of an internship program sponsored by the Great Lakes CPSU at U/WI-Madison.

For a 30 year time frame, Figlio determined the benefits to the local economy acerued from tourism spending, park salaries and expenditures, and payments in lieu of taxes. He then compared these benefits to costs due to loss of logging opportunities and lakeshore development. Results showed that economie benefits of the park's establishment greatly outweigh the costs, even when maximum lakeshore development and liquidation logging praetices are considered.

The results will be used to counter local perceptions that the park has negatively impacted the local economy. Other parks may find Figlio's methodologies useful for showing how resource preservation makes economic sense. Copies of the complete report are available from Pictured Rocks. A less technical version is available in the park's series of Resource Reports. For more information, contact Resource Management Specialist Brian Kenner, Pictured Rocks NL, P.O. Box 40, Munising, MI 49862; (906) 387-2607.

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From Jack Oelfke, Natural Resource Specialist at Isle Royale NP, and Rolf O. Peterson, Michigan Technological University at Houghton, comes word of the 35th annual winter study program of wolf/moose monitoring at Isle Royale. The program, a cooperative effort with the park and Dr. Peterson at MI/Tech/U, ran from Jan. 14 to March 2, 1993. Previous trends were maintainted – the wolf population remained at 12 animals while moose population continued to grow to its highest level in 60 years – close to 1500 animals.

Two wolf pups born in 1992 countered the loss of two adult loners (one was never found, the second was killed by other wolves when it strayed into that pack's territory). The present 12 animals are organized into three packs; the single reproducing pack has increased to seven members; the other two packs consist of two wolves each. Only one lone wolf is present. Three females, one from each pack, were in breeding condition and courted in 1993, however only one pack has successfully raised young since 1988.

Chronic wolf population decline led to more intensive studies beginning in 1988. Disease may have played a role in the population decline, but the current belief is that genetic loss is primarily responsible for lack of recovery. Genetic analysis of several Island wolves indicates that all are descended from a single female, probably a founder of the population. Substantial genetic variability has been lost, leading to inbreeding depression or reduced reproductive success arising from genetic isolation of a small breeding population.

Current expectation is that the wolf population will die out on the Island, although when is not known. Of the 10 animals of known sex, only three are female. Live-trapping and collaring of animals continued in 1993, raising the number of collared animals to six. Monitoring continues throughout the summer and early fall.

National Capital Region

The Rachel Carson House in Silver Spring, MD was dedicated as a National Historic Landmark on April 18. Dr. James L. Sherald, Research Plant Pathologist and IPM Coordinator for NCR represented the NPS at the dedication. Sherald spoke of the advances made in IPM in the NPS and on Rachel Carson's influence on pest management throughout the world.

Western Region

Recent evidence indicates that amphibians are declining on a global basis. Healthy, seemingly well-protected populations have disappeared for no obvious reason, even from parks and large wilderness areas. At the same time, the status of amphibians has been poorly documented and little research has specifically addressed these issues. Dr. Gary Fellers, Research Biologist at Point Reyes NS, has begun a three year study of declining amphibians in California parks, to:

- Assess the status and distribution of selected amphibians in nine park areas.
- Evaluate possible causes of amphibian declines.
- Determine the feasibility of experimentally reestablishing frog populations that have been lost.
- Determine the genetic diversity of selected amphibians that might be used in reintroductions.
- Develop a monitoring program that will allow the NPS to monitor key populations.

* * *

The Second Biennial Conference on Research in Colorado Plateau NPs will be held on the campus of Northern Arizona University, Flagstaff, AZ, Oct. 25-28, 1993. Hosted by the University and the NPS/CPSU at NAU, the conference will highlight biological, cultural, social, and physical science research in national parks and related areas on the Colorado Plateau.

* * *

Charles van Riper III, Unit Leader and Mark Sogge, Ecologist, both of the NPS/CPSU at NAU, are authors of a new publication, ***Changing nest placement of Hawaiian Common Amakihi during the breeding cycle***, in Wilson Bulletin Vol. 105. Sogge attended a meeting of the Cooper Ornithological Society in Sacramento and delivered a paper on ***Status of the Southwestern Willow Flycatcher along the Colorado River in Grand Canyon***; Van Riper, at the same meeting, gave a paper titled ***A comparison of avian hematozoan epizootiology in two California coastal scrub communities***. Research Ecologist Peter G. Rowlands, also of the NAU/CPSU, has had accepted for publication in Southwestern Naturalist a paper on ***Climatic factors and the distribution of woodland vegetation in the Southwest***.

* * *

Six Technical Reports (Nos. 45 through 50) were published by the NPS/CPSU at U/CA Davis in October 1992, and five 1993 Technical Reports (Nos. 4 through 8) are currently in preparation. For titles of the reports, which range widely over subject matter from Bighorn Sheep reintroduction in the Sierra Nevada to Great Grey Owl Hunting Behavior in Yosemite, from kelp forest monitoring in the Channel Islands to characteristics of nine forest stands in Sequoia NP, write to the NPS/CPSU, Wickson Hall, U/CA, Davis, CA 95616, or call Unit Leader Stephen Veirs at (916) 752-6086.

* * *

Sequoia and Kings Canyon NPs were represented at the conference on "Fire in Wilderness and Park Management: Past Lessons and Future Opportunities," held in Missoula, MT March 30-April 1. Poster presentations were made by Tom Ritter, David Parsons, Mark Finney, and MaryBeth Keifer.

In late May, Sequoia/Kings Canyon hosted a Principal Investigators' workshop for all PIs working on the Sierra Nevada global change research program. Also, Research Scientists David Parsons, David Graber, and Nate Stephenson are cooperating with the USFS in developing a proposal for in-depth analysis of the status of old growth forest and associated ecosystems in the Sierra Nevada.

* * *

In March, 1993, the Division of Humanities and the Environmental Studies program at U/CA Santa Cruz co-hosted the second in a series of University conferences with the common title "Reinventing Nature." According to David Graber, Research Biologist at Sequoia/Kings Canyon NPs and the NPS/CPSU at U/CA, the intentionally ambiguous title refers to powerful concepts of invention and deconstruction applied to nature, wilderness – even the science of ecology.

To what extent is "nature" a cultural determination? How possible is it to know the actual structure of nature? How durable is the American myth of wilderness in the light of revelations about the long-term plasticity of the continent and interactions of

Continued on page 22

native Americans with the pre-Columbian landscape? The way these questions are answered, Graber suggest, may have profound consequences on the way national parks are managed in the future.

Graber's invited paper was entitled *Resolute biocentrism: managing for wildness in national parks* and he has promised *Park Science* an article in a future issue based on what he terms "the most important scholarly meeting I have attended in my NPS career."

* * *

4 NP Videos Win Awards

K.R. Cranson, with Lansing Community College's science department, alerts *Park Science* to four new videos made in national parks that won awards at the 30th National Outdoor-Travel Film Festival sponsored by the Michigan Outdoor Writers Association. Cranson's review of the videos will be carried in the Fall issue of *Park Science*.

Southwest Region

A three-year study, a cooperative effort by the NPS/CPSU at NAU and the AZ Game and Fish Department, will examine the physical and biological factors influencing Arizona pronghorn habitat use. Objectives are to determine pronghorn movements within, into, and out of park boundaries, to identify home ranges of the pronghorn herds and core use areas within and outside the park, and to determine pronghorn fawn behavior and the influence of vegetation structure on pronghorn fawn mortality.

The study also is being conducted in Petrified Forest NP, to compare to Wupatki NM data. The project is being supervised and administered by Van Riper and NPS/CPSU Wildlife Research Biologist Henry E. McCutehen.

Pacific Northwest

A superbly conceived and executed 14-panel folder, ***Wildflowers of Craters of the Moon National Monument***, has been produced and is on sale for $2 by the Craters of the Moon Natural History Assn. The full color folder is pocket size, with photos of the Monument and 14 of the plants to be found there. Portions of the text are adapted from ***Common Plants of Craters of the Moon NM***, by Karl A. Urban. Each plant photograph has a check-off box beside its description, for easy record-keeping.

* * *

The NPS held its annual Rivers, Trails, and Conservation Assistance (RTCA) training in Portland, OR April 18-23, 1933. This year's training focused on environmental negotiation and upon involving culturally diverse and economically depressed communities in the care and management of their natural resources. PNR Director Charles Odegaard has committed to providing staff resources for planning and developing the Evergreen Agenda, an initiative underway in Washington State to create a community-based statewide system of natural and open space lands.

* * *

The first ever biologieal survey of the Oregon Caves was earried out in 1992 by Rod Crawford, an invertebrate specialist at U/WA's Burke Museum. This initial effort found more than 20 species inhabiting the cave. Two, and possibly three, of the species had never before been known and occur nowhere else in the world. One is a millipede of the genus *Speoseya*, a species represented elsewhere by only two specimens. The seeond is a water mite, likely parasitie on a yet-unknown species occurring in the cave.

A third specimen, a grylloblatid, is suspeeted to be a new species but this cannot be confirmed until a male is found. Grylloblatids are primitive insects found mostly in ice fields and in lava eaves. They have always been found in glaciated or formerly glaciated areas. The eurrent find conforms to this pattern. Glaciation has oceurred within 2,000 meters of Oregon Caves, and the grylloblatid is believed to be a glaeial reliet. The pit-traps, baited with limburger cheese, are still set in the cave and are checked by park staff every 20 days. The survey is continuing in 1993 and will be tied to a five-months-long Earthwateh project.

themselves to the edge of chaos, and so too do Stuart Pimm's and Jim Drake's ecological models. No one can say yet whether individual ecosystems do the same thing, but the data from mass extinetions at least suggest that, globally, they do. 'That's a powerful message of a powerful instrinsic dynamic," said Chris. 'Systems poised at the edge of chaos achieve exquisite control, and I believe you see that right the way up to Gaia.'

"If it's true that, for instance, ecologieal communities move toward the edge of ehaos, where novel properties emerge (such as foodwebs and the ability of a long-established community to resist invasion by alien species), then it seems legitimate to talk about sueh communities as real systems. It may even be legitimate to think of them as behaving and evolving as a whole, analogous with the superorganism concept that Ed Wilson talked about in connection with soeial inseet colonies. Coevolving communities act in concert as a result of the dynamics of the system; they do so as a result of individuals within the community myopically optimizing their own ends and not as collective agreement toward a common goal; and the communities really do come to know their world in a way that was quite unpredictable before the science of Complexity began to illuminate that world."

* * *

Troubling complexities is the title of an artiele by I. Peterson in the Sept. 5, 1992 issue of *Science News* (p. 157). In it, Peterson states:

> *In studies of the dynamics of biological systems, researchers face the dilemma of determining from experimental data whether observed variations represent random fluctuations or the chaotic state of a deterministic system. If they can demonstrate that the system is chaotic rather than random, they have a better chance of developing a strategy to understand and control this erratic behavior.*

Peterson quotes Leon M. Glass of MeGill University in Montreal: "Complex aperiodie rhythms that are observed in natural systems might be due to deterministic chaos, random 'noise.' or some combination of the two different mechanisms. Thus, the interpretation of the dynamical basis of complex aperiodie rhythms in natural systems is a diffieult and hotly debated topie."

Information Crossfile

The June 10,1993 issue of *NATURE* announces the successful cloning of DNA from a previously unknown species of weevil that was preserved in fossilized amber (hardened tree sap for at least 120 million years. George Poinar, Jr., an entomologist at U/CA Berkeley and four other scientists have now pushed back the earliest known date for cloning DNA to 120 to 135 million years ago.

* * *

The April 1993 issue of Florida DNR's ***Resource Management Notes*** contains an account of how Hurricane Andrew devastated exotics, exultantly headlined "Native Victory Garden." Renate Skinner, Florida Region 7 biologist, describes Australian pines (*Casuarina equisetifolia*) over 60 feet tall – some four to five feet in diameter at the base – downed, scattered, and "stacked on the ground as if they were mere saplings." Triumphantly still standing, ("wedged between the fallen giants,") were native strangler figs (*Ficus aurea*), seagrapes (*Cocoloba uvifera*), and sabal palms (*Sabal palmetto*). Sea oats (*Uniola paniculata*) still thrived; four known endangered plant species at Cape Florida survived; "and then there was the gratifying discovery that the native vegetation in the designated 'Natural Zone' still existed - doubly gratifying, since in the early 1980s the area was on the way to becoming a parking lot. Park and regional staff efforts prevented this by pointing out the spontaneous, prolific growth of native plants which had occurred there after Australian pines had been toppled in a minor windthrow."

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Runoff Report is the name of a new publication started by the National NonPoint Source Federation, P.O. Box 30101, Kansas City, MO 64112. Billed as "a watershed information network news," *Runoff Report*'s Spring 1993 (Vol. 1, No. 1) issue, welcomes "corporate, environmental, governmental, and grass roots interests from all sections of the country." Incorporated in Missouri as a not-for-profit organization, the Federation is headquartering in Kansas City, with membership regions corresponding to ecoregions. An electronic bulletin board will be on-line within several months and planning is underway for a regional workshop and national conference.

* * *

Sinauer Associates, Inc. of Sunderland, MA (01375-0407) announce publication of ***Ecology and Our Endangered Life-Support Systems***, Second Edition, by Eugene P. Odum. The 300+ page soft cover volume, with 91 illustrations ($18.95), presents a "big picture" look at ecology. It includes updated, expanded coverage of experimental life-support systems, ecotones, diversity, energetics, agroecology, succession, mutualism, evolution, ecological economics (!), waste reduction, global concerns (such as ozone holes and climate change) and ecosystem types, especially wetlands. Charles van Riper III will review it for the Fall issue of *Park Science*.

* * *

State of the World, 1993, the 10th annual edition of the Worldwatch Institute Report on progress toward a sustainable society is now available in both hardcover ($19.95) and paperback ($10.95). The Institute's ***Vital Signs 1992: The Trends that are Shaping Our Future***, (same prices as ***State of the World***) tracks environmental, economic, social and health trends plus significant new patterns that are emerging. When ordering (from Worldwatch, 1776 Massachusetts, Ave., N.W., Washington DC 20036-1904) include payment and Worldwatch will pay the shipping charges.

* * *

A Memo from the GWS Executive office, introducing the Vol. 10, No. 1, 1993 issue of the ***George Wright FORUM***, discusses "A National Biological Survey: Some Issues, Concerns, and Historical Background." Without taking sides, the authors consider the mechanics of creating a separate agency and the series of questions thus raised: "Will the NBS increase or decrease U.S. NPS direct access to scientific expertise for dealing with resource issues? Will the U.S. NPS have to pay NBS to do the research?

"Will the current trend within U.S. NPS... toward the use of research information in decision-making and the emphasis on resource management... be reversed if U.S.NPS scientists are removed as internal advocates? Who would be left within the U.S. NPS to advocate research?

"Where will national parks and other protected areas fit into the NBS's priorities? Since parks and other protected areas are such a small part of the country's land base, and because there may be a perception that they are not as much at risk as multiple-use lands, how much attention will they receive in a national inventory?

"How will the NBS react to changing politics in the Secretary of the Interior's office? Could a future, less supportive Administration undermine long-term projects? Could such an Administration manipulate the results?

"Might a career ladder develop in which junior scientists cut their teeth in the U.S. NPS, only to move on to the NBS to address national level biological concerns?"

* * *

Richard West Sellars, U.S. NPS historian based in Santa Fe, NM at the NPS SW Regional headquarters, is the author of a forthcoming history of natural resource management in U.S. national parks. A three-part series of excerpts from the book began in the *George Wright FORUM*, Vol. 10, No. 1, pp. 55-77. The series is dedicated to Victor H. Cahalane, who headed the programs from the mid-1930s to 1955. Part 1 is entitled "The Rise and Decline of Ecological Attitudes in National Park Management, 1929-1940.

* * *

William H. Rodgers Jr., a professor of law at U/WA, Seattle and chair of a National Research Council committee on federal land acquisition, is quoted in the *Gazette-Times* (Corvallis, OR) May 20 editorial page in favor of the development of a common information base on the part of the four different agencies that hold the most federal land– BLM (270 million acres), USFS (191 million acres), USFWS (89 million acres), and NPS (76 million acres).

"Each agency has its own criteria and procedures to buy new land... but the agencies' priorities are poorly coordinated, and the process used to submit their proposals to Congress makes the problem worse... [The method used] forces wildlife refuges in the Florida Keys to compete with the Civil War Battlefield at Gettysburg. It does not address larger goals or long-term plans, such as protecting entire ecosystems," Rodgers said. "... the four agencies and the OMB need to develop a new approach. They should begin by separating the current ranking system into at least three categories: outdoor recreation resources, natural resources, and cultural resources... They then need to develop a common interagency information base. Amazingly, the government now has no comprehensive source of information on privately held lands that it might want to buy. It does not even have such a data base for the land it already owns."

* * *

"Any close reading of the past 12 years forces us to the tragic conclusion that politics within the natural resoures agencies has, for all practicaly purposes, driven science out of the decision-making process whenever science comes into conflict with any opportuni-

Crossfile continued from page 23

ty for private profit from the public lands. Until there is a mueh better publie understanding of the major publie lands issues and conflicts, we will continue stumbling blindly along the same destruetive course."

Thus spoke former Sen. Gaylord Nelson (now with The Wilderness Society, Washington, D.C.) at the George Wright Society's 7th Conferenee on Researeh and Resource Management in Parks and on Publie Lands in Jacksonville, FL in November 1992. The address is carried in the *GWS FORUM*, Vol. 9, Nos. 3 and 4, pp. 8-16. Bill Brown's Letter from Gustavus, "A New Day Dawning," leads off the volume, the rest of which is devoted to papers from a workshop organized by the GWS and IUCN at the 4th World Congress on National Parks and Protected Areas, Caracas, Venezuela, February 1992.

* * *

An 88-page full color book, *A Protected Areas Vision for Canada*, produced by the Canadian Environmental Advisory Council and forwarded to *Park Science* by its principal author, Kevin MeNamee, is available free from Publication Centre, Environment Canada, Ottawa, Canada, K1A 0H3.

* * *

Report of a Workshop for National Park Service Ecological Research Program, edited by Drs. Paul G. Risser and Jane Lubchenco, is available from Mike Ruggiero, NPS Division of Wildlife and Vegetation, P.O. Box 37127, Washington, DC 20013-7127. The report discusses findings from the workshop sponsored by the W&V Division and the Southwest Region, held in February 1992.

* * *

Planning for the Future: A Strategic Plan for Improving the Natural Resource Program of the NPS, is an illustrated description of four overall goals to direct the actions of the natural resource program and of the several objectives contained in each goal. Copies of the 16-page publication, edited by Lissa Fox and Jen Coffey and designed by Todd Hampson, may be had by calling (202) 343-1000.

Albright Expands Leadership and Management Course

By Mark J. Maciha and Jim Corless

In January 1993, the Facility Manager Development course at Albright Employee Development Center became the NPS Leadership and Management Course. The former course had, for five years, been instrumental in meeting the call for highly trained managers in the maintenance field. The new version was developed through the efforts of NPS managers in four fields, to include trainees in maintenance, interpretation, law enforcement, and administration.

Thirty-six personnel, mostly supervisors–some line, some division chiefs–from these four disciplines attended the first session of this course and chose to name their class after newly appointed Secretary of the Interior Bruce Babbitt. They felt that Secretary Babbitt exemplifies the revitalization of the Department and of the NPS that class participants are striving for.

The five-weeks course was made possible through efforts of the Employee Development Office, the WASO Divisions of Interpretation, Maintenance, and Ranger Activities, and the regional administrative offices. Countless opportunities were provided for the group to approach problems from a multidisciplinary perspective, using the diversity of the group's knowledge and skills. The result was a coming-together not only in locality, but intellectually.

A team approach developed quickly, as participants became first roommates, then as co-workers to solve case studies and exercises, and finally as friends, who discussed creative solutions for addressing their park concerns. They came to recognize the different perspectives of the disciplines and capitalized on those differences in preparing class assignments, in addressing their own park issues, and in resolving misunderstandings about different divisions.

It became apparent how diversity in personal and work styles could be used in a complementary way to produce a more exciting and productive work environment. Decision making, time and risk management, communications, negotiation, media relations, and managing change–all were components of the curriculum. Sessions on planning interfaced well with presentations on resource management issues.

Participants, who said they often were at odds with other divisions in the parks, found they were able to meet management objectives far better when they worked with other disciplines from the very start of planning or problem solving. This training will be reinforced when the participants go on their individual four week details to other park areas, primarily with different divisions, to broaden their experience and put their new learning to the test. A counselor, selected for each participant, helped trainees develop goals and objectives and project assignments.

A perceived shortfall of the course was the scarcity of the trainees' resource management expertise compared to their experience in their principal disciplines. Although the course agenda included resource management topics and case studies, all exercises shared by the class would have been more meaningful with representation of resource management specialists' perspectives. An integrated approach to resource management and protection is critical, not only between cultural and natural resources, but among all park divisions. This course contributed to awareness of resource issues among all participants and will facilitate integrated approaches and solutions to resource management issues.

Class members adopted a plan–a set of objectives and actions–to further their self-defined mission: "To strengthen the pride and vision of the NPS by empowering people through creative leadership and an interdisciplinary team approach."

Maciha is South District Ranger at Death Valley NM; Corless is Chief, I&RM, at Hopewell Furnace NHS.

Crater Lake Final Report

Limnological studies of Crater Lake were initiated by NPS in 1982 in response to the suggestion that characteristics of the lake were changing because of human activities around the lake. The final report of these studies is in the final stages of preparation under the direction of Gary Larson, a Research Scientist with the CPSU at Oregon State University.

A draft of the report, which describes a wide array of studies of biological and physical properties of the lake, was distributed for review in December 1992. On Feb. 27, 1993 a panel of scientists met at OSU to discuss the report. Members of this peer review panel were Stanford Loeb, chairman, U/KS; Raymond Herrmann, with NPS at CO/State/U; Hiram Li with the Oregon Cooperative Fishery Research Unit of USFWS; Manuel Nathenson, with USGS in Menlo Park, CA; Richard Peterson, with Portland State/U, OR; and John Stoddard, with the U.S. EPA, Corvallis Environmental Research Laboratory.

High Altitude Mountaineering: Visitor Types and Management Preferences

By Alan Ewert

A recent study at Denali NP identified some of the characteristics of the mountaineering visitor, the climbers' perception of the mountain environment, and certain preferred management options affecting the mountain environment and the mountaineer on Mt. McKinley and adjacent Alaska Range peaks. To date, the research community has paid little attention to such areas in terms of who the participants are, what are the underlying reasons for their visits, and what types of management issues are at stake.

Approximately 360 registered climbers were asked to complete a 26 item questionnaire as they checked out at the ranger station in Talkeetna. Response rate for the questionnaires was close to 100 percent; 84 percent attempted the West Buttress route and the remaining 16 percent climbed the Muldrow, West Rib, or Cassin. Since this study was exploratory in nature, the questionnaire was printed only in English. The sampling began in June and was concluded in August. It covered approximately 36 percent of the total number of climbers registered to climb McKinley in 1992.

Who Is the Climber?

Of the climbers responding to the questionnaire, the average age was 32 (range=18-62). Within this group more than 90 percent were male. Climbers reported an average of 10 years of mountaineering experience. It should be noted that the sample was skewed toward the low end of numbers of years of mountaineering, with over 40 percent of the sample reporting six or fewer years of experience.

Within the sample, 67 percent indicated that they made the summit or completed their route. Of these, the reasons for their success included (in descending order of importance): Preparation, experience, acclimatization, food, good weather, patience/perseverance. The primary reasons given for not summiting or completing the route included: Bad weather and sickness/medical problems. The majority of the people (66%) were classified as independent climbers (not a member of a guided party), with 32 percent being part of a guided party and 2 percent being solo climbers.

The Mountain Environment

By a wide margin, the majority of climbers utilized the Southeast Fork Kahiltna landing strip. As depicted in Figure 1, levels of trash were perceived differently at various locations. Of all the locations reported in the study, the campsite at 17,200 feet on the West Buttress was the only consistently reported area to have trash problems.

In dealing with trash, the vast majority of climbers reported carrying out their trash. This was followed by dropping it in a crevasse (14%), and burying (1%). A note of caution here: Carrying out garbage is the administratively correct thing to do; without an actual behavior observation there is no way to ascertain the accuracy of these "reported" actions. On the other hand, it should be noted that filling out the questionnaires was voluntary and anonymous.

A number of suggestions were made by climbers on how to handle trash. The more popular ones included: Carrying it out, education, establishing collection sites and using helicopters to remove it, and burning it. Currently, NPS policy emphasizes a carry-out procedure; burning trash is not allowed.

Regarding human sanitation on the mountain, human waste disposal was not a problem at base camp for most climbers (72%). In camp locations, only 3 percent reported that disposing of human waste was a problem that detracted from their mountaineering experience. On their climbing route, 30 percent reported that human waste disposal was a problem.

Ninety percent of respondents reported they used plastic bags for human waste disposal in crevasses; however, the questionnaire did not determine whether climbers used this method all the time or interspersed it with other techniques. Problems in disposing of human waste included: Not enough latrines, inadequate directions on how to dispose of human waste, too severe environment to adequately use plastic bags or build latrines, and latrines inadequately placed. Possible solutions listed by climbers were: Limit number of parties, have more plastic bags available and *enforce* a human waste disposal policy, furnish more latrines, dump stations, and chemical toilets. Currently, NPS recommends using plastic bags as latrines and then disposing of the bags in deep crevasses.

Continued on page 27

Figure 1. Levels of Trash at Various Locations (in percent).

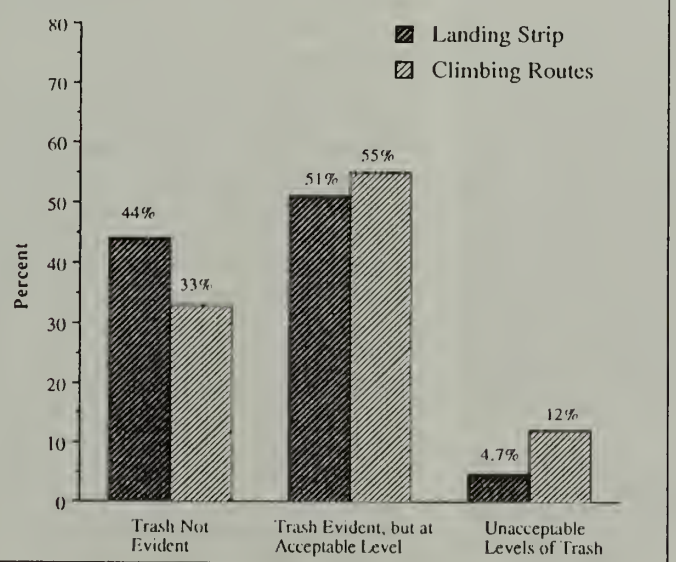
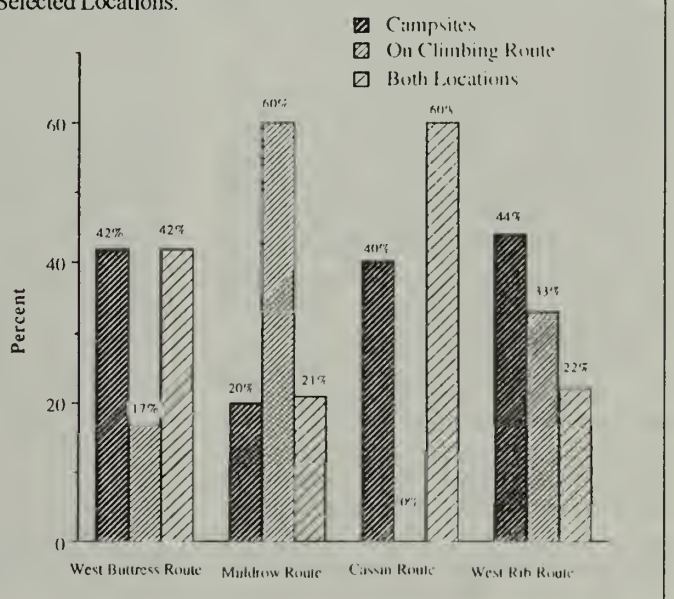


Figure 2. Percent of Climbers Reporting Crowded Conditions at Selected Locations.



Wildland Fire Management at Carlsbad Caverns NP

By Tim Stubbs

Carlsbad Caverns NP in the Guadalupe Mountains of Southeast New Mexico is widely known for its ornate caves, but not for its 47,000 acres of nearly pristine wilderness. The vegetation is mostly representative of the Chihuahuan Desert biome. It can be characterized as a plant community normally dominated by grasslands and interspersed with areas of shrubs and agavaceous succulents and cacti.

Surface water is scarce; riparian areas are limited to a few places along normally dry washes. Both pinon-juniper (*Pinus edulis* and *Juniperus scopulorum*) and forested areas are found in the park's higher elevations (generally above 6000'). The latter are found only on the extreme west end of the park and are composed of disjunct timber species such as ponderosa pine (*Pinus ponderosa*), douglas fir (*Pseudotsuga mensziesii*), and white pine (*Pinus stobiformis*), more widely found to the north in the Southern Rocky Mountains.

Periodic and sometimes large prairie and timber fires are well documented in both written and verbal records from the 19th and the early part of the 20th centuries. Considerable evidence, both in historical accounts and in tree ring studies, indicates that most of what now is Guadalupe Mountains NP to the west of Carlsbad Caverns burned in one large fire around the turn of the century. A few large (around 10-33 thousand acres) wildfires also occurred in this century, most caused by summer lightning.

Prevention and suppression of vegetation fires has taken place throughout most of this century; the great majority of detected natural lightning ignitions have been quickly suppressed. Heavy grazing of the herbaceous vegetation by cattle, sheep, and goats has taken place concurrently. This substitution of sustained unnatural disturbance (grazing) for the periodic natural disturbance (fire) has allowed the colonization of many areas with various fire sensitive and unpalatable shrubs such as spreading juniper (*Juniper pinchotti*), catclaw (*Mimosa biuncifera*), and creosote (*Larrea tridentata*), and the unpalatable succulents lechuguilla (*Agave lechuguilla*), Sotol (*Dasylirion leiophyllum*), and prickly pear (*Opuntia spp.*).

Beginning several years ago, park managers endeavored to exclude trespass livestock that was migrating into the park from adjacent private and federal lands by fencing the perimeters of both parks. This sudden cessation of heavy grazing, coupled with abnormally wet years, produced a bumper crop of grass and other herbaceous vegetation intermingled with the aforementioned shrub and succulent vegetation. The resulting fuel situation has been shown by several recent fires in and around to readily sustain almost any ignition not immediately rained out or suppressed. Successful suppression in these fuel conditions has been shown by woeful experience to be unlikely in view of the hot, dry, and windy weather typical of spring and early summer months. Fuel reduction is clearly called for in many areas if any subsequent suppression efforts are to be successful.

The park also contains a substantial wilderness area within its boundaries. The mandates of the Wilderness Act of 1964 and of NPS policies governing management of wilderness areas have dictated that we consider reintroduction of naturally ignited vegetation fires as a natural resource management tool.

The Park Fire Management Program

A Fire Management Plan has been drafted and approved for Carlsbad Caverns that includes both "prescribed natural fire" and "management ignited prescribed fire" as tools for achieving certain natural resource management and fuels management goals.

A prescribed natural fire (PNF) is defined as a wildland fire ignited by natural means (usually lightning), which is permitted to burn under specific prescribed conditions, in a preplanned location, and with adequate fire management personnel and equipment available to achieve certain defined resource management objectives. A management ignited prescribed fire (MIPF) is similarly defined except that MIPF is intentionally ignited by park management, where specific prescribed conditions and fire location usually are more precisely defined.

The introduction of this program to park neighbors and neighbor agencies has not been without substantial resistance. Land adjacent to the park is sparsely populated but contains valuable gas and oil facilities and ranchlands, and memories are still fresh of the Cottonwood Fire (1974, 16,000 acres) and the Big Fire (1990, 33,000 acres). Neither of these wildfires had regard for park boundaries and both presented major threats to outlying ranches and gas/oil facilities. The specter of prescribed natural fires becoming similar raging wildfires is unacceptable, and every attempt has been made to coordinate park planning with that of all adjacent property owners and jurisdictional agencies around these relatively small tracts of NPS land.

The park's fire management plan describes strict prescription limits for prescribed natural fire behavior. Since the park is surrounded on most of its boundary by Bureau of Land Management (BLM) and U.S. Forest Service (USFS) lands, the park's plan delineates a conditional suppression strategy zone for its boundary area. The strategy for this buffer zone is identical to that specified by neighbor agency fire management planning documents. Any ignition in the boundary areas of the park/BLM/USFS (or any PNF that approaches this area from the interior of the park) will be managed in an appropriate suppression strategy (confine, contain, or control) as determined by a unified command of all involved/concerned agencies. MIPF is proposed for natural resource management purposes in lieu of PNF in the proximity of park boundaries and around high visitor use areas of the park. In these areas an increased degree of control is necessary and the uncertainties of PNF (i.e. the timing of the treatment vs. the availability of control forces) are unacceptable. MIPF in these areas also will create "defensible space" of reduced fuels in the likely event of a PNF or wildfire in these areas.

Wildland Fire Research Needs

Research in the form of intensive fire effects monitoring must be involved in every step of the implementation of this program. Some examples of current research needs are:

- The effects of fire in the park on flora and fauna have been qualitatively researched only cursorily; there is scant information as to the effects of fire on hydrology, cultural resources, etc. Quantitative baseline data on species composition and density need to be established and monitored through several burn/recover cycles under the strictly controlled and monitored conditions of MIPF. With this data we can ascertain the effects of fire on the park's natural and cultural environment in general and on affected flora, fauna, and watershed in particular.
- Current theories concerning fire frequency for the park are based largely on incomplete historical records or on suppression-era ignition data. Tree ring, charcoal deposit, or similar studies could ascertain more correctly the fire frequency in the Guadalupe Mountains, particularly in the Carlsbad Caverns area.
- The current vegetation composition is almost certainly unnatural, as complete fire suppression and heavy grazing have been the rule throughout most of this century. Photographic reviews, pollen and opal phytolith, or similar studies would help park managers ascertain the "natural" vegetation composition of the park.

Resource Management SCA student Amy Rusk monitors fire behavior during a Management Ignited Prescribed Fire in the park. Vegetation transects were laid out prior to the burn and monitored during the burn and will be monitored in the years to come.

- All known colonies of the nationally listed eacti Lee's Pineushion (*Corypanthus sneedi var. leei*) in Carlsbad Caverns NP are currently protected in full suppression zones because the effects of fire on this species are largely unknown. The USFS and USFWS have conducted recent studies adjacent to the park to determine the effects of wildfire on this species. Preliminary reports are that intense broadcast fire not only seems to have little long-term effect on individual specimens but may even aid in the plant's propagation. Several of our known populations are in easily accessed areas in which it would be relatively easy to execute MIPFs. We should establish interagency ties to study the effects of fire of various intensities on this federally protected plant.

Fire Management's Future at Carlsbad

Prescribed natural fires will be allowed to burn, with extreme sensitivity to the concerns of neighboring agencies, park visitors, and park neighbors. These fires will be carefully monitored to learn the effects of fire on natural resources and to ascertain and certify the capabilities of park management at deploying this inexpensive but powerful natural resource management tool.

Management ignited prescribed burns will be conducted to ascertain both the direct and the indirect effects of fire on all aspects of the park's natural environment. Various academic institutions will be encouraged to address the park's fire research needs, possibly through subsidized research funds currently available through FIREPRO (NPS wildland fire management funding) sources. Through MIPS we will continue to establish research-based goals and objectives derived from properly conducted research, which will include documentation of fire effects in various intensities, and the validation of prescriptions necessary for achieving these goals/objectives.

Suppression of all fires that do not qualify as PNFs (including all non-MIPF human-caused fires) will continue. The park will maintain a cadre of highly trained wildland fire personnel to properly monitor prescribed fires and to professionally supervise wildfire suppression efforts when these become necessary.

Stubbs is Fire Management Officer at Carlsbad Caverns NP.

High Altitude Mountaineering continued from page 25

Sociological Factors

Given the international popularity of Mt. McKinley and the increasing numbers of climbers over the past decade, the issue of crowding was considered an important study element. Although the size and complexity of Mt. McKinley would seem to preclude a crowding problem, only a few routes receive the majority of use. In this study, 32 percent of the climbers reported crowding as a problem. As shown in Figure 2, perceived crowding varied with the location. For example, crowding was prevalent on the Muldrow route and non-existent on the Cassin route.

On the issue of limiting the number of climbers, a slight majority of respondents were against limitation (57% to 43%). These numbers might change if climbers were actually faced with being denied a climbing opportunity on the more heavily traveled routes. When asked about ways to deal with the crowding problem, two responses were most often given: Establish a permit system, and limit group sizes.

The literature now is fairly consistent in differentiating between solitude, user-density, and crowding (Patterson and Hammitt, 1990; Stewart and Carpenter, 1989). While density can be an actual physical measurement (numbers of climbers in a given location), solitude and crowding are psychologically determined. In the case of crowding, how "crowded" an area is depends in part on the expectations and past experience of the individual. At Mt. McKinley, climbers (particularly on the more popular routes) may be expecting to see larger numbers of other climbers and consequently feel less "crowding" even though a relatively high user-density obtains.

Conclusions

Drawing conclusions from a one-time snapshot of people and time can be a risky business. Some information from this study bears up under the weight of common sense, experience, and past findings from the literature. The demographics from this study's sample are congruent with the general population of climbers visiting Mt. McKinley. To the extent that this is true, it would seem reasonable that they reflect many of the views and demographics of most McKinley climbers. It should be noted however, that the study did not sample those climbing in the earlier part of the season—April and May. The variables of age, gender, and years of mountaineering experience do seem in line with the overall climbing population of Mt. McKinley.

Trash and human waste are problems in some areas but not overwhelming for most climbers. Most-offered solutions, such as crevasse dumping or helicopter-assisted removal, either are not new, or represent a significant increase in maintenance and personnel costs.

The study showed that trash, sanitation, and crowding still are within acceptable limits for most Mt.McKinley users. If problems eventually do occur in these or other areas related to management of the climbing environment, future studies should strive to determine what types of solutions or management options would be most acceptable to the user.

Dr. Ewert is Branch Chief, Recreation, Wilderness, and Urban Forestry Research, USFS, Washington, DC

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Stewart, W. and E. Carpenter, 1989. Solitude at Grand Canyon: An application of expectancy theory. Journal of Leisure Research 21(1):4-17.

Effects of Fire on Cultural Resources at Mesa Verde NP

By William H. Romme, Lisa Floyd-Hanna and Melissa Connor

On Oct. 20-21, 1992, twenty-five archeologists, ecologists, and fire managers met in Mesa Verde National Park (MVNP) to evaluate and predict the effects of fire on the park's cultural resources. Our goal is to develop a risk model--incorporating parameters of potential damage to sites and artifacts, vegetation/fuels conditions, and weather conditions--that will be useful to managers in predicting and managing fire effects in Mesa Verde and similar parks in the southwest. This report addresses the first component of the risk model, namely the differential susceptibility of various types of cultural sites and materials to damage from high intensity fire effects.

Three general questions were: (1) What are the major types of cultural sites and materials in MVNP and what are the direct and indirect effects of high intensity fires on each type? (2) What kinds of monitoring and damage evaluation should be conducted before, during, and following high intensity fires? (3) What kinds of pre-suppression activities can be taken to reduce damage to cultural resources?

We focused only on high intensity fires because these are potentially most damaging and difficult to control. Following is a summary of our conclusions and recommendations for further studies.

Effects of Fire on Different Kinds of Cultural Resources

The several types of historic and prehistoric cultural sites identified are listed below in approximately descending order of susceptibility to direct damage by fire. Additional details and evaluation of fire impacts on these kinds of cultural resources can be found in the assessment of the Long Mesa fire that occurred in MVNP in 1989 (Eininger 1990, Fish 1990) and the annotated bibliography compiled by Duncan (1990).

A. Sites with high vulnerability:

1. Native American historic structures: These include sweat lodges, corrals, and similar structures. Wooden structures are destroyed by fire and leave little trace. Protection during fire is nearly impossible. Many of these structures are sacred for the people who use or used them.

2. Alcoves and cliff dwellings: Combustible materials--e.g. packrat middens, wooden beams, corn cobs--are consumed by fire. Many alcove sites are relatively protected from fire because they are surrounded by expanses of bare rock with no fuel. But organic materials can be ignited by firebrands or spontaneous combustion through pre-heating from an intense fire burning all around the alcove.

3. Rock art panels: Rock art occurs in MVNP, but no known panels were within the boundaries of the Long Mesa fire. A comprehensive inventory of rock art panels within MVNP does not exist and undocumented panels may have been affected by the fire. Studies in upper Salt Creek in the Needles District of Canyonlands NP indicate that exfoliation of the rock face occurs during high intensity fires (Noxon and Marcus 1983 a,b). Prevention measures include clearing brush from areas around the rock face. Other methods, including application of a stone strengthener (organo-silcon compounds in a ketone carrier), also may help prevent exfoliation (Grisafe and Nickens 1991).

4. Scarred trees: Several old trees in the park were scarred by Native Americans, probably Ute people, who stripped the bark for food some time prior to park establishment in 1906. These trees could be killed by high intensity fires and their tree ring record lost.

B. Sites with moderate vulnerability:

1. Euro-American historic structures: Most of these structures are associated with park management, e.g. the Recreation Hall and Museum on Chapin Mesa. Some of these may be defensible in moderate intensity fires, but several cannot be protected from high intensity fires.

2. Lithic scatter with shallow hearth: Due to its ephemeral nature and the emphasis on structural features, this site type may be under-recorded within MVNP. As the effects of fire are strongest at the surface, artifacts here will be vulnerable to damage by fire. Surficial lithic materials within the Long Mesa fire boundary showed color alteration due to heating. This would not impair analysis of their technological attributes or their function based on morphology. Studies on silca-rich stone suggest that low fire temperatures are responsible for minor morphological change in surface cherts at Long Mesa. Beyond about 700F (350C) stone will spall, crack, and shatter (Mandeville 1973; Purdy and Brooks 1971). In a hotter fire or on a different type of stone, the potential exists for changes to stone artifacts that impair morphological analyses.

Due to the increased luster associated with heating of cherts, heating probably would impair microwear analysis, as it would impair blood residue analysis. However, as neither of these analyses are routinely successful on surficial material, this is not a serious loss.

Effects of fire on a shallow hearth are more problematic. Common archeological analyses of hearths include studies of the way the hearth was made, their pollen, faunal, and macrobotanical contents, and dating techniques such as radiocarbon, thermoluminescence, and archeomagnetic dating. The study of hearth construction does not appear to be affected by fire.

Effects of fire on hearth contents have been studied. Fish (1990) conducted a study on effects of fire on pollen and found that even the surface samples marked by ash and charcoal from the Long Mesa fire yielded abundant, identifiable pollen. She found that pollen grains that appeared to be fire-altered by the Long Mesa fire "were darkened to a yellowish-brown color and would not absorb the stain used to enhance microscope viewing. Walls of these grains were thickened or swollen and fine morphological features were obscured, although identifications were still possible" (Fish 1990:2-3). Shipman and others (1984) document the effect of fire on bone, showing color change and calcining in surficial bone at lower temperatures. Ashing occurs at high temperatures. Calcined surficial bone was observed within the Long Mesa fire boundary. Ford (1990) found the Long Mesa fire did no damage to ethnobotanical material from hearths within the fire boundary. Thus, almost counterintuitively, it appears that wildfires such as the Long Mesa and La Mesa fires have little impact on study of the contents of shallowly buried hearths.

The third factor affecting the research potential of these hearths is dating. Although not studied as a result of the Long Mesa fire, wildfire burning over a shallow hearth probably would affect the potential for use of thermoluminescence and archeomagnetic dating. That wildfire affects both analyses was demonstrated in studies after the La Mesa fire in Bandelier NM (Rowlett and Johannessen 1990; DuBois 1990). No controlled studies on the effect of wildfire on radicarbon dating exist. However, inclusion of recent charcoal from a wildfire into a radiocarbon sample would result in significantly younger date.

C. Sites with low vulnerability:

1. Deeply buried unexcavated pueblos: Fire produces discoloration and oxidation of surface ceramics and lithics. Eininger (1990)

Alcove conaining a small Anasazi stone building. The Long Mesa fire in 1989 burned the forest above and around this alcove, but did minimal damage to the archeological site because of the lack of fuel directly within the alcove.

Boulders that were cracked by sudden and intense heating in the Long Mesa fire of 1989. Prehistoric rock walls could be damaged by cracking and spalling of this kine.

summarizes what is known about these effects and the temperature thresholds at which they occur. At very high temperatures (ca 600C), carbon may be burned out of sherds, leading potentially to misidentification. Fire also accelerates decomposition of sandstone blocks. Accelerated rock decomposition could create future difficulty in recognizing sites on the basis of surface components. Deep structures probably are unaffected by fire, since heat rarely penetrates more than a few cm even in intense fires (Chandler et al. 1989).

Fire apparently has little impact on the research value of deeply buried sites except in two circumstances. First is buried pueblos with large trees on or adjacent to the site; the roots may burn in a high intensity fire and carry heat down into the buried structures (Wettstead 1988), and the charred roots remaining in the soil may confuse charcoal dating and interpretation. The second potential effect occurs immediately below large logs that smolder, driving the heat as deep as 20 cm into the ground at that spot (Connor et al.1989)

Fire retardant slurry could affect standing walls if it is dropped directly on the walls during suppression activities. Slurry weight could knock down walls, and geologist Mary Griffiths suggests the slurry may be incorporated into sandstone rock where it hastens decomposition.

2. Lithic scatter: See discussion on surficial lithic material under section dealing with lithic scatter with shallow hearths.

3. Check dams: Fire apparently has little or no effect on check dams.

Indirect Effects of Fire

Several indirect effects may occur either immediately or months after a fire. Potentially important indirect effects include:

1. Rodent and insect populations may increase in response to increased succulent vegetation following the fire; rodent burrowing disturbs artifacts and alters their positions.

2. Bare soil exposed by fire is vulnerable to erosion and redeposition during the time period before vegetative cover becomes reestablished (Connor and Cannon 1991, Swanson 1981). These processes may remove artifacts or bury them.

3. Microbial activity may increase after fire (Bissett and Parkinson 1990). Potential effects on cultural materials are unknown, but probably result in short-term accelerated decomposition of organic materials.

4. Application of fire retardant slurry during suppression activities may affect cultural artifacts; details are lacking. The U/CA at Riverside is conducting studies of slurry effects in Joshua Tree NP, but results are not yet published. The phosphorus in the retardant also may influence post-fireplant growth and composition, since phosphorus is a limiting plant nutrient in most ecosystems.

Pre-suppression Opportunities for Reducing Fire Damage

We started with the assumption that high intensity wildfires will occur in MVNP in the future: given the climate, fuels, and topography, occasional uncontrollable fires are inevitable. See Erdman (1970) and Omi and Emrick (1980) for discussion of fire history and future fire potential in the park. Below is a list of things that can be done to minimize damage to individual sites and materials before the next uncontrollable fire occurs.

Some of the actions are expensive; others may not be feasible immediately. Rather than embarking on a crash program to "harden" all cultural resources against fire, we suggest that park managers should incorporate these steps into their long-range planning and do each at an opportune time. Some damage to sites will occur even without fire: natural processes of weathering and erosion have been occurring for centuries and will continue, regardless of our actions. Suggested pre-suppression activities are listed in approximately descending order of urgency.

(1) Document sites and artifacts that cannot be protected from high intensity fire. Several kinds of cultural resources are highly vulnerable to wildfire and cannot be effectively protected. The only way to ensure that information they contain is not lost is to document them thoroughly. The park already has a program of inventory and analysis of these kinds of resources, but the program must be accelerated. We recommend the following specific actions:

(a) Contract a qualified persons(s) to inventory and estimate approximate age of packrat middens; then contract the same or another person to perform a thorough scientific analysis of a sample of the oldest middens. These contain among the best records available of variations in climate and vegetation over the last 20,000 years (e.g. Betancourt et al. 1990); and they are, obviously, irreplaceable.

(b) Locate and photograph the scarred trees throughout the park. Then contract a dendrochronologist to collect increment cores. The tree rings will reveal the date the tree was scarred and a record of climatic variation.

Continued on page 30

(c) Map, photograph, and describe Native American and Euro-American historic structures and evaluate whether any additional pre-suppression activities, such as localized fuel reduction, would be practicable.

(2) Reduce fuels selectively in localized, high value areas. It is not feasible or necessarily even desirable to try to reduce fuel loads throughout the park; fuels are so great and variable and other resources would be damaged in the attempt. However, small but highly significant areas present opportunities to reduce fuels. The inventory of sensitive cultural resources should include evaluation of the feasibility and value of fuel reduction around each site. A risk analysis team then should review the list and select the sites for fuel reduction. They should have high cultural significance, high risk from fire, and a setting where fuel reduction is feasible.

Fuel reduction may be accomplished mechanically, by prescribed burning, or by a combination. The existing hazardous fuel reduction program could be expanded to accomplish this. Following is a list of some of the methods that may be practicable:

(a) Removal of dead and down woody material, thinning of the forest canopy (30-foot or 60-foot spacing), and thinning of brush around historic structures.

(b) Removal of brush and trees from the vicinity of alcoves and cliff dwellings (may need to be repeated periodically).

(c) Removal of trees growing in or adjacent to buried pueblos or hearths. Sites having standing walls would receive higher priority for this work than sites with only rubble on the surface.

(3) Evaluate all the existing sites and interpretive facilities and assign each a priority rating for trying to save it in a high intensity fire. Much of this kind of assessment already has been done, but it needs to be expanded to include all such structures in the park. The ranking system must be presented explicitly to all park workers to reduce confusion and controversy during a large fire. Each type of cultural resource should be evaluated independently, as well as in comparison with all other cultural resources. The assigning of a priority ranking should be carried out by a risk assessment team of both cultural and fire people. Priority assignments will call for value judgments and these should be stated explicitly by the risk assessment team and if necessary debated long before a large fire demands immediate decisions.

(4) Build fire resistant features into new and existing park buildings and interpretive structures wherever possible. This can be accomplished over many years. Fire personnel should be involved in planning future construction and renovation, to see that fire resistant features are built in wherever those features are consistent with the primary purposes of the structure. Examples follow:

(a) When roof repairs become necessary, replace existing shake shingles with fiberglass or other reproductions that look similar but are vastly less flammable.

(b) When the curtains on the ruins shelters need replacement, use fire resistant material. In the event of a high intensity fire, the curtains then provide some protection for expensive interpretive features inside.

(c) Install sprinkler systems in or around highly significant but vulnerable structures.

Romme is a professor at Fort Lewis College in Durango, CO; Floyd-Hanna is a faculty member at San Juan College in Farmington, NM; and Connor is with the NPS Midwest Archeological Center, Lincoln, NE.

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In the next issue...

- "New Fossil Mammals Found at Florissant Fossil Beds," by Emmet Evanoff and Peter M. de Toledo, indicating that the Florissant Formation was deposited at the same time as the Chadon Formation of Badlands NP
- "Seasonal and Diurnal Discharge Fluctuations in Nedano Creek, Great Sand Dunes NM in Southern Colorado," by James P. McCalpin
- "Evaluating Eastern Wild Turkey Restoration at Indiana Dunes National Lakeshore" (using GIS analysis), by Eddie L. Childers
- "Succession and Biological Invasion at Mesa Verde NP" (weed species invasions following hot fires), by Lisa Floyd-Hanna, William Romme, Deborah Kendall, Allan Loy, and Marilyn Colyer
- Part I of an overview of the "Shared Beringian Heritage Program," by Dale Taylor and Jeanne Schaaf

MAB Notes

Curtis Bohlen, former Assistant Secretary of State for Oceans and International Environmental and Scientific Affairs, has appointed Dr. Frank H. Talbot as the **new chairman of the U.S. MAB National Committee**. He will serve for three years, 1993-1995. Dr. Talbot is Director of the National Museum of Natural History at the Smithsonian Institution. He succeeds Dr. Thomas Lovejoy, who served for five years. Under Lovejoy's chairmanship, U.S. MAB streamlined its structure by reducing the 14 directorates to 5. It began core directorate projects, and concentrated MAB upon interdisciplinary social and natural science research. In leaving his MAB post, Dr. Lovejoy noted "that the greatest assets of U.S. MAB are the biosphere reserves themselves ... [but] we have yet to come success fully to grips with how we can capitalize on this impressive network ... The ... biosphere reserve managers workshop currently being organized will be a significant step in that important direction."

Regional MAB and MAB-related programs are progressing all around the country. For example, planning activities are underway in the Sonoran Desert, Ozark Highlands, Champlain-Adironodack Area, Colorado Rockies, and western Lake Superior. Regional work on the ground continues in the Mammoth Cave Area, the Southern Appalachians, and the Central California Coast. Since these regional progams are working examples of cooperation in implementing biosphere reserve concepts, I will highlight one in each MAB Notes column.

The **Central California Coast Biosphere Reserve** (CCCBR) was established in 1988. The first biosphere reserve to involve a major urban area, it is culturally and ecologically extremely diverse, with an impressive array of management, research, and educational institutions. Its 13 public and private land and water units, centered in the San Francisco area, include Audubon Canyon Ranch; Bodega Reserve of the University of California, Davis; Cordell Bank and Gulf of the Farallones National Marine Sanctuaries; Farallon National Wildlife Refuge; Golden Gate National Recreation Area; Jasper Ridge Biological Preserve of Stanford University; Marin Municipal Water District; Mt. Tamalpais, Samuel P. Taylor, and Tomales Bay State Parks; Point Reyes National Seashore; and the San Francisco Water Department Peninsula Watershed Lands.

A feasibility study funded by U.S. MAB and a subsequent planning report funded by the Marin Community Foundation guided development of the CCCBR structure and operating procedures.

The work of the CCCBR is planned by councils; three–Managers, Science, and Education–have been established. Two others–Sustainable Economic Development and Public Participation–will be created when leadership is identified. The councils' activities are facilitated by the non-profit CCCBR Association.

The Association's Board of Trustees consists of the Chairs of each Council and additional representatives from science, education, and other communities. The Board reviews Council proposals for the Association's endorsement and support. The Association receives funds from government agencies and private sources for carrying out projects of the biosphere reserve.

A Memorandum of Understanding, signed in 1992-93 by agencies and organizations participating in the biosphere reserve, sets forth the background and objectives of the BR program. It is not surprising that getting the signatures of BR administrators and other interested parties took some time, as agencies and organizations had to be assured that the agreement would not conflict with their individual mandates. The CCCBR's office is at Fort Mason, in Golden Gate NRA. The CCCBR sees itself primarily as a coordinator, convener, and facilitator of communication for the many groups engaged in resource management, conservation, environmental education, and research on natural and human systems in the central California coastal region. Several projects are underway. One is organization of a symposium on biodiversity of the central California coast, including the greater San Francisco Bay region. The symposium, to be held in winter 1993-94, will look at the status of biodiversity in the region, the resources at risk, and strategies and tools for sustaining biodiversity. Another project is development of an integrated GIS system for the CCCBR. This involves determination of the present GIS capacities of the CCCBR member agencies, and development of a questionnaire to obtain information needed to identify objectives and assess opportunities for an integrated GIS system. The general goal is to improve the information base for multi-sector and cross-boundary resource management and restoration and to improve the utility and cost effectiveness of existing GISs.

With a dedicated, well-functioning Board, clear project goals, and a small but growing bank balance, the CCCBR appears to be off to a good and promising start.

Napier Shelton, NPS Wildlife and Vegetation Division, WASO.

A PhotoPoint Archival System

By Stephen V. Cofer-Shabica

Case and others (1982) describe a system of documenting natural and human-related physical changes in natural and cultural resources within units of the National Park System. The documentation system has multiple uses, is aesthetically unobtrusive, and sufficiently permanent to provide natural and cultural resource base information today and in the future.

The preservation of the photographic products (in this case, 35mm color transparencies, black and white negatives, and B&W color-separation negatives) is discussed. They suggest that metal cabinet-type slide storage files or metal slide storage boxes be used for the archival storage of original transparencies, and the B&W negatives. Regardless of the method used, they caution that the environment surrounding the storage area be temperature and humidity controlled, to ensure long-term preservation.

The maintenance of a constant temperature/humidity environment often is difficult in parks. Thus, in 50 to 75 years, as the color dyes fade, the recorded images will lose much of their information. Black and white color-separation negatives are costly, since three negatives are required for each preserved image. These negatives also need proper temperature/humidity control, although it is not as critical as with the color transparencies.

Advances in computer technology over the past five years have provided a means of archiving photographic products over long periods of time. The introduction by the Eastman Kodak Company of a compact disc (CD) photographic process provides photographers and resource managers with a relatively permanent, inexpensive, and easily stored means of archiving photographic slides, negatives, or prints. This system allows up to 100 color transparencies to be placed on one CD, at a current cost of less than $20 per disc. The photographs may then be displayed either with a Kodak Photo CD Player connected to a television, or a CD ROM (XA) drive connected to a personal computer. In addition, duplicate copies of the photographs can be reproduced from the CD as well as additional discs made.

The use of the compact disc for storage of critical natural and cultural resource photographs and color transparencies should allow managers to archive such products permanently.

Cofer-Shabica is Resource Management Specialist at Cumberland Island National Seashore.

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The use of trade names does not imply U.S. Government endorsement of commercial products.

Letters

To the Editor:

I wanted to let you know that I was pleased with our recent articles on inventory and monitoring in *Park Science* (Fall 1992 and Winter 1993 issues). The layout was attractive and effective in conveying the rather lengthy discussion in the text.

I was amazed at the response that we had to these articles. We had requests for information and publications from many different agencies, universities, and other institutions. Our research program clearly gained a higher degree of visibility and credibility on a national basis because of these articles. The contact with non-NPS scientists has been particularly helpful in developing additional linkages for our program outside the agency.

I am not sure if all your articles get this much response, but *Park Science* was certainly an effective forum for getting the word out, both within and outside the NPS. I appreciate your assistance with our articles and enjoy every issue of *Park Science*. Keep up the great work!

David L. Peterson
Assoc. Prof., Univ. of Washington
NPS Research Biolgist, NPS/CPSU at U/WA

Editor's Note: A letter from Scott F. Poser of the Canadian Ministry of Natural Resources recently arrived, asking for missed copies of Park Science, (the result of a gigantic distribution snafu), and adding: "I am particularly interested in the series of articles dealing with the development of Inventory and Monitoring programmes in U.S. National Parks as I am working on a project with a similar aim for Ontario Provincial Parks."

These things are good to hear.

Biology Colloquium Explores Harmony With Nature

Ruth Jacobs, Research Assistant with the NPS/CPSU at Oregon State University, attended the 54th Annual Biology Colloquium held at OSU April 29, 1993, where the question explored from many angles was "How can humans live in harmony with nature?"

Speakers covered the subject matter from the abstract to the specific and applied–from "Three Philosophies of Conservation," (by Richard B. Norgaard with U/CA-Berkeley) to "The Concern for Human Population Growth in Conservation Issues" (Anne Ehrlich with the Center for Conservation Biology at Stanford).

Of particular concern in the Pacific Northwest were two lectures by Drs. E. Charles Meslow (USFWS) and David Ehrenfeld (Rutgers U Dept. of Natural Resources). Dr. Meslow addressed the controversy over logging in the Pacific Northwest and conservation of spotted owls. In 1987, he said, we assumed that 300 acres of land per pair of owls was sufficient. That judgment was based on the best data then available. Today, he said, we recognize that a pair of these owls uses several thousand acres of forest, with a strong dependency on old-growth systems. User groups and management agencies have struggled to deal with this changing base of knowledge at the same time that local and global demands for forest products have increased.

"In the case of the spotted owl," he said, "we have avoided decisions outright... when our knowledge warned us to do otherwise. In other instances, we have postponed reasonable decisions that would alter ongoing management programs pending more information."

We still have options for owl conserva-tion, he noted, "but they are fewer and more limited."

Dr. Ehrenfeld argued that humans live in an increasingly artificial reality. "Many of us," he said, "don't even care about our natural world, although we are intricately tied to it, because we have lost touch with reality."

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PARK SCIENCE
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Restoration of Estuarine Tidelands In South Slough National Research Reserve

Editors Note: Simply adding water "doth not a wetlands make." The importance of wetlands – their preservation and restoration – is increasingly making itself felt on the national consciousness. In the following article, the problem of restoring an estuarine ecosystem is painstakingly addressed by a formidable group of scientists, willing to acknowledge the long-term nature of any such re-creation. The South Slough project is blazing a remarkably thorough and honest trail in the wetlands restoration wilderness – one that will be of intense interest to NPS site managers with similar problems.

By Steven S. Rumrill and Craig E. Cornu

Estuarine habitats in the Pacific northwest have been functioning at less than full ecological capacity for nearly a century. In most cases, estuarine channels, mudflats, and saltmarshes have been dredged, diked, and drained for timber and agricultural purposes. Research and management staff members at the South Slough National Estuarine Research Reserve (NERR) are working together to reverse the enduring effects of estuarine habitat degradation with a restoration strategy that will accelerate re-establishment of full estuarine wetland functions to a series of neglected agricultural lands.

The Winchester Tidelands are an integral component of the 5,000 acre South Slough National Estuarine Research Reserve located on the southern Oregon coast near Coos Bay. Situated at the Estuarine Turbidity Maximum (ETM) along the western arm of the estuary, the Winchester Tidelands historically consisted of highly productive estuarine channels, mudflats, and salt marshes. The majority of these tidal lands were diked and removed from tidal circulation to promote draining, crop production, and other agricultural uses around the turn of the century. These alterations of the landscape resulted in loss of critical habitat for anadromous fish, migrating waterfowl, shorebirds, invertebrates, and mammals. As a consequence of diking and draining activities, the Winchester Tidelands currently exist as a series of degraded agricultural lands and freshwater drainage channels.

Once a salt marsh, this area is now largely a neglected pasture with a narrow region of estuarine influence. Steve Rumrill considers mechanisms to accelerate the rate of estuarine recovery.

The Winchester Tidelands Restoration Project (WTRP) will remove old earthen dikes and tide gates to restore tidal circulation, eelgrass beds, and native salt marsh vegetation to ca 75 acres of degraded agricultural lands. In addition, the WTRP provides outstanding opportunities to accelerate restoration of estuarine processes to degraded coastal wetlands, and to address important research and educational issues during the course of habitat restoration.

Marsh Subsidence and Invasive Species

Successful restoration of estuarine functions to the WTRP area will require solutions to several significant problems. First, removal of historic marsh lands from tidal inundation has resulted in subsidence of the marsh base to an elevation approximately 1 to 2 feet below normal levels. Marsh elevation is critical to habitat function in tidal marshes because elevation determines the ratio between exposure to air and submergence beneath brackish water. Desirable target marsh plants (e.g. *Juncus balticus*, *Jaumea carnosa*, *Deschampsia caespitosa*) have relatively narrow tolerances for tidal inundation. Since the rate of ambient sediment accretion is slow at 3-4 mm per year, recovery of the WTRP marshes to their original elevations is likely to take 70-100 years or longer. Moreover, the restoration activities will take place within an estuarine landscape that is replete with invasive species.

The initial stages of estuarine wetland recovery are characterized by a transitional period of disturbance that opens the way for invasive exotic plant and animal species to colonize recovering marshes. In addition, tidal waters within the South Slough NERR are inhabited by more than 40 species of non-

Continued on page 4

PARK SCIENCE

NATIONAL PARK SERVICE

FALL 1993

A report to park managers of recent and on-going research in parks with emphasis on its implications for planning and management.

ARTICLES

DEPARTMENTS

Editorial

The National Biological Survey: Opening Day

By Dr. F. Eugene Hester

In the last issue [see Summer 1993] I explained the concept behind the creation of the National Biological Survey (NBS), a non-advocacy biological research and inventory agency in the U.S. Department of the Interior. Oct. 1, 1993 is the date scheduled for NBS's opening day. The NBS Implementation Task Force continues to work energetically to ensure the transition is smooth.

Earlier this month, Assistant Interior Secretary for Fish and Wildlife and Parks George Frampton asked me to continue on with NBS after October 1 as Deputy Director. It is an honor I gladly accept.

NBS becoming a bureau on October 1, however, depends on several steps involving the Congress and the Secretary of the Interior.

To date, three NBS authorizing bills have been introduced–two in the Senate and one in the House. None of the bills was voted on by Congress before its summer recess; however, Congressional leaders have been supportive of the NBS, as reflected in the House vote action and Senate Committee mark up of the FY94 NBS budget.

Since budget authority is expected–even if a Continuing Resolution should be operative on October 1–Secretary Babbitt will be able to establish the NBS through a Secretarial Order. While the Secretary is cooperating fully with Congress, authorizing legislation is not required for the new bureau to open its doors.

So what will be the picture on October 1, when NBS formally begins operation? For scientists in universities, research centers, and in the field, the picture will look very familiar. In fact, for most of FY94, the picture may be nearly indistinguishable from the current one. While more than 1,700 employees will be transferred administratively from other Interior bureaus to the NBS, not one person has been identified who will have to undergo a geographical move that would involve a change of residence. Nearly all available positions within the new bureau are expected to be filled through the lateral transfer of employees within programs being moved. We are expecting that it will be a number of months before the Eco-regional Offices are established as well.

It is a rare occurrence in the career of a federal employee to have the opportunity to participate in the creation of a new agency. This is an exciting time for everyone involved in this process, and a promising time for improving our understanding of ecosystems through research, inventory and monitoring, and information transfer.

For some further thoughts on NBS, see page 31.

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Fort Clatsop Schedules Wetlands Restoration

By David A. Ek

Fort Clatsop National Memorial is located at the convergence of the Oregon Coast Range and the lower Columbia River estuarine wetland system. Approximately half of the 125.1 acre park is fresh water or estuarine wetland. The other half consists of young to mature coastal spruce/hemlock forest. Historically, the park and surrounding area had been impacted and altered by the creation of dikes and other water diversions, land use conversions to agriculture and industrial developments, and intensive forestry practices.

Management of these forests and wetlands is becoming more difficult, due to increasing development and encroachment--impacting the natural and cultural resources of the park. Park plans include restoring the Memorial's wetlands that were altered by diking projects prior to creation of the park. This complex project will consist of removal of all or part of the dikes, construction of new dikes to prevent flooding of adjacent private lands, removal of part of the existing vegetation, possible lowering of portions of the surface topography, and continuous monitoring throughout.

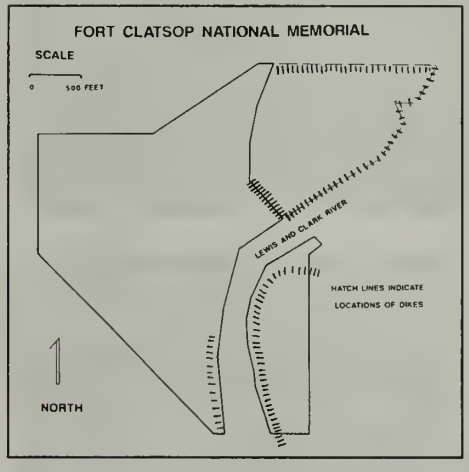
Even if the project is successful and the end result is not an anaerobic quagmire, any such habitat change of this scale will create dramatic changes in the hydrology, soil, flora, fauna (including microbial), and topography (including visual characteristics as well as social perceptions). All of these aspects will need to be carefully addressed in the wetland restoration plan.

An important concern is that large portions of Fort Clatsop NM's wetlands lie beyond the current park boundary. To begin dealing with these and other issues and concerns, the General Management Plan and Resource Management Plan currently are being rewritten. These draft plans identify the need for boundary expansion and Congressional lifting of the Memorial's current 130-acre boundary ceiling.

These plans, along with several inventory and monitoring projects either recently started or proposed for funding, are the first of a long series of steps in the restoration of the important wetlands of Fort Clatsop National Memorial.

Ek is Resource Management Specialist at Fort Clatsop NM.

Park Ranger, Ricardo Perez (right), and Biological Aid, Doug Johnston, along the Lewis and Clark River Estuary of Ft. Clatsop National Memorial.



The solid line represents the boundary to Fort Clatsop National Memorial; the dashed line represents property planned to be donated to the park by the Fort Clatsop Historical Association.

Dollar Value of Wetlands

"...But as far back as 1974, Eugene Odum, director of the University of Georgia's Institute of Ecology, extrapolated the dollar value of seafood resources that wetlands nurtured. He also calculated the worth of the waste assimilation, water purification, and flood control functions marshes performed, and determined that in sum, an average acre of wetlands provided $50,000 a year in goods and services to society."

Edward Flattau,
Columnist

Newspapers of Aug. 11, 1993

"...At issue is funding for the Wetlands Reserve Program [under which] farmers with eligible land can offer to restore it to permanent wetlands status in exchange for a government payment. The program would bring about a host of environmental benefits while dramatically reducing the amount of money in federal disaster aid that the government would have to spend in aid to people whose properties have been destroyed by flooding."

Michael Zimmerman, *Dean*
College of Letters and Science
University of Wisconsin, Oshkosh

native invertebrates. Post-implementation monitoring will track colonization of the recovering marshes by target plant and animal species, and will identify problems posed by the invasive exotics.

WTRP Advisory Group: Partnerships for Planning

Veterans in the field of estuarine recovery have noted that few, if any, dedicated estuarine habitat restoration projects along the Pacific coast have gone through a comprehensive process including scientific design, implementation, and monitoring. These shortcomings place severe constraints upon the status of the rapidly emerging ecotechnology of restoration science (Zedler, 1986; Simenstad and Thom, 1993).

The WTRP will fill an important gap by making use of an experimental approach to accelerate restoration of estuarine processes. In order to proceed with critical decisions regarding restoration and research within the Winchester Tidelands project marshes, South Slough NERR staff members assembled an advisory group to seek technical expertise on restoration options and development of project protocol. Personnel selected for the group were chosen from nationally recognized experts in the fields of estuarine ecology, botany, hydrology, and habitat restoration, and included members from state and federal agencies, academic institutions,and private industry.

During a workshop held at South Slough NERR and the U/OR Institute of Marine Biology (June 28-30, 1993), the multi-disciplinary team (1) helped articulate project goals and objectives, and (2) contributed to the design of a phased restoration plan for the WTRP.

The primary goal of the WTRP is to carry out restoration activities designed to re-establish estuarine processes within diked modifed habitats encompassed by the Winchester Tidelands Project area. The Advisory Group also established several objectives: **(a) Habitat Function:** restore lost habitat functions to a diversity of regions including salt marshes, mudflats, and tidal channels within the Winchester Tidelands project area, **(b) Research:** conduct empirical research to gain a more complete understanding of the response of natural estuarine processes to the initiation of restoration events, **(c) Education:** provide resource decision makers with guidance and technical information regarding restoration of estuarine habitats, and **(d) Management:** manage the WTRP to emulate a natural system that will require minimal external maintenance.

Aging tide gates (right) allow some tidal flow through the earthen dikes (above) that dominate the Winchester Tidelands landscape. (*Photos by Steve Rumrill*)

Acceleration of Estuarine Recovery

The WTRP Advisory Group considered a series of restoration options, hydrologic constraints, and functional criteria to design a multi-phased implementation plan:

Phase 1. Collection of Baseline Information

Baseline information will be collected from the Winchester Tidelands Project marsh sites, a series of off-site diked and naturally breached marsh sites, and natural (or control) marsh sites located within or adjacent to the South Slough NERR. The baseline survey will include topographic and bathymetric mapping, installation of permanent stream gauges and water quality meters, assessment of historic marsh elevations from peat cores, analysis of aerial photographs, and quantitative field surveys (sediment accretion rates, sediment types, soil salinities and redox potential, plant community composition, utilization by fish and benthic invertebrates).

Phase 2: Active Breach/Passive Restoration

Old dike materials at the Kunz site will be redistributed within the pasture to construct a temporary earth-berm that will separate an existing *Typha* (cattail) marsh from remaining portions of the diked pasture lands. Portions of the old dike will be removed at the location of the historic tidal channel mouth to re-establish tidal connections with the South Slough estuary. These activities will require redistribution of ca 1,200-1,5000 yd^3 of old dike material. Natural processes (tidal inundation, sediment accretion, and successional

Topographic mapping is currently underway (below) at the Kunz site. (*Photo by Steve Rumrill*)

vegetative colonization) will be allowed to continue passively to restore estuarine functions to a 7-acre region. It is expected that full recovery of estuarine processes in this region will require 70 to 100 years.

Phase 3: Active Breach/Experimental Restoration

In an experimental attempt to accelerate marsh recovery, the base elevation of portions of the Kunz site will be raised to re-establish appropriate tidal elevations. Existing dike materials will be redistributed to separate the remaining portions of the site into 3 experimental restoration marshes and a control marsh (approx. 1.7 acres each). The failing Kunz pasture tide gate will be removed and topsoil recovered during removal of the existing Kunz dike will be used to regrade the experimental restoration marshes in a series of 3 basic elevations:

- Control marsh – existing elevations (subsidence to -1.2 ft)
- Experimental marsh #1 – low/mid marsh elevations
- Experimental marsh #2 – mid/high marsh elevations
- Experimental marsh #3 – high transitional marsh elevations

The existing Kunz dike will be breached at four points to allow tidal waters to inundate the control and experimental marshes. These activities will require redistribution of ca 9,000-12,000 yd^3 of old dike material. It is expected that full recovery of estuarine processes will be accelerated within the graded series of experimental marshes and that lost habitat values will be restored after 20-40 years. Complete development of restored marsh structure and function will be monitored over a long-term (>50 yr) monitoring/research program.

Phase 4: Improved Implementation of Restoration Activities

Information derived from the Kunz experimental restoration marshes will be used to help plan and implement restoration of the remaining marshes in the Winchester Tidelands Project Area. Activities carried out during the final phases of implementation will include salvage and stockpiling of existing marsh plants and native eelgrass, eradication of non-native plants (especially Himalayan blackberry and reed-canary grass), construction of multiple training channels to control tidal scour and erosion, and reconstruction of Dalton Creek and Cox Canyon streambeds with gravel bottoms, woody debris, and multiple overhangs to provide habitat for native cutthroat trout and coho salmon. Once these tasks are complete, existing tide gates will be removed from all westside project marshes and portions of existing dikes will be removed or lowered to reintroduce full tidal inundation and flushing.

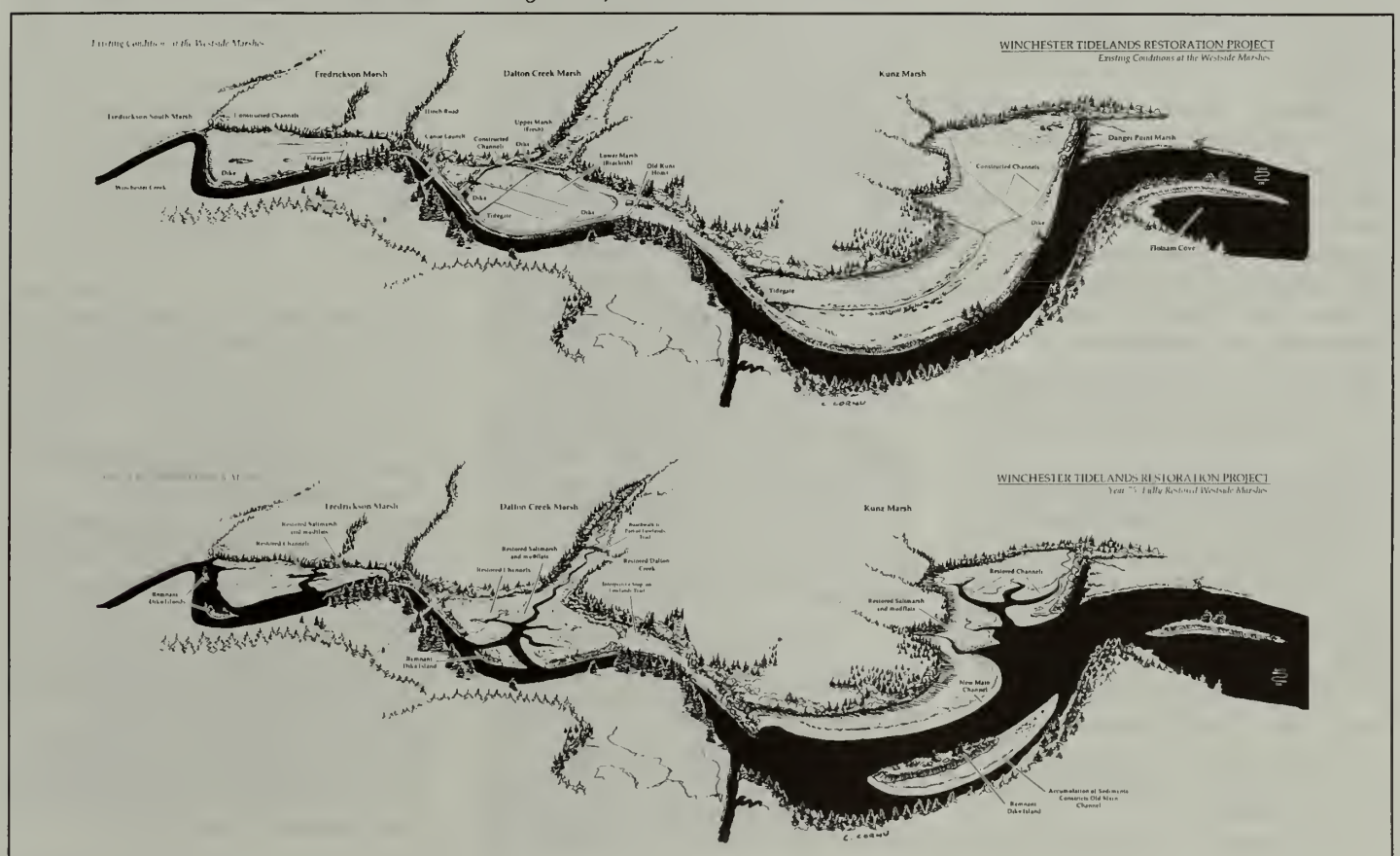
Phase 5: Monitoring

Recovery of estuarine habitat elements (tidal channels, mudflats, salt marshes) will be monitored following the implementation of restoration procedures. Intensive monitoring will continue for at least 8 years and will focus on the critical evaluation of structural and functional attributes. Evaluation of structural attributes will include assessments

Continued on page 6

Aerial photo of the Kunz site at high tide. Note tidal water within diked area due to failing tide gate. (*Photo by Mike Graybill*)

Bird's eye perspective drawings showing existing (above) and restored (below) conditions at the WTRP sites. (*Drawings by Craig Cornu*)



New Natural Resources Directory Available on Discs

A new Natural Resources directory, in disc form, is now available, providing the latest (and easily updatable) information on all National Park System sites identified by the Regions as having significant natural resource activity (the approximately 250 "I&M" parks). A software manual that comes with the disc describes the system, its rationale, its components, its maintenance, its various uses, and how to submit changes in the system's information as such changes are needed.

The manual is in WP5.1 and contains information on all natural resource-connected personnel by Regions. Abby Miller, Program Coordinator for the NPS Associate Director of Natural Resources, notes that "there are a few missing persons due to nonresponsiveness to requests for information." She further notes that "researchers seem to be disproportionately among the missing."

Field personnel who wish to be listed and have not yet responded may remedy this situation by contacting their Regional Resource Management Chiefs and providing the information needed. Washington Office (WASO) personnel and organizations who are not presently listed may contact Jon Paynter in Miller's office [(202) 208-4640] for inclusion.

The NPS Natural Resource Personnel Directory Software is a dBase III+ data base system (Clipper-compiled) that allows a user to produce the NPS Directory on his or her local PC. The user can run a series of reports, either to the screen or as a hardbopy paper output. Many of the paper reports can be quite lengthy. It is hoped that in most cases the screen reports will provide the needed information, thereby saving paper and space on a shelf.

In addition to running the "canned" reports that come with the software, users are able to create their own formatted reports using the STAFF.DBF file and a copy of dBase III Plus.

Bajada Takes Prize

Bajada, the newsletter produced by CPSU/UA won first runner-up in the category "internal color newsletter" in a nationwide contest sponsored by the weekly publication *Government Computer News* (GCN). Seventy entries, all from government agencies, had been submitted for 12 categories. This is the first time GCN has run this contest, and the results have been reported successful enough to repeat the contest next year. An article reporting the results will appear in the desktop publishing government supplement of GCN September 13.

Interpretive Handout

Napier Shelton of the Washington Office (WASO) Wildlife and Vegetation Division sends word of a "nice little interpretive handout" titled "Forests and Interesting Trees in the National Park System," now available from the WASO Public Inquiries Office in main Interior, (202) 208-4747, (Room 1013), 18th and C Sts. N.W., Washington, DC 20240. The 10-page piece was produced by the Wildlife and Vegetation Division in response to requests from Public Inquiries and was sent also to selected National Parks.

Restoration of Estuarine Tidelands continued from page 5

of tidal circulation, evaluation of marsh vegetation and productivity, composition of infaunal and epibenthic invertebrate communities, and establishment of rates of sediment accretion.

Evaluation of functional attributes will include assessments of hydrologic function and water quality, estimation of food chains support, and development of breeding habitat and forage areas for fish and wildlife. The temporal trajectories of habitat recovery will be identified during the monitoring process, and recommendations for remediation and enhancement will be developed.

Benefits for Coastal Wetland Elements

Construction of dikes and levees has been the most widespread and destructive activity leading to loss of estuarine channels and intertidal marshes in the Pacific northwest (Boule and Bierly, 1987; Frenkel and Morlan, 1991; Simenstad and Thom, 1993). Estuarine wetlands have been identified as temporary residence areas for juvenile salmon, and estuarine channels within South Slough NERR currently support limited populations of Coho, Chinook, Chum, and sea run Cutthroat trout. These anadromous fish are considered sensitive species throughout the southern Oregon coast by the OR Dept. of Fish and Wildlife (UDFW, 1992). The WTRP will provide valuable temporary residence and feeding habitat for juvenile salmon, and will emphasize practical implications for salmon resource management and habitat protection.

In addition to benefits for anadromous fish, restoration of tidal circulation within the Winchester Tidelands also will increase habitats for local populations of threatened plants and migratory shorebirds. The South Slough NERR also provides critical year-round habitat for several sensitive species including Bald Eagles, river otters, black bears, and cougars; habitats within South Slough NERR are used on a temporary basis by Peregrine Falcons, Long-beaked Curlew, and several other migratory shorebirds.

Benefits from the Winchester Tidelands Restoration Project will include documentation of resource benefits and changes in habitat quality that result from tidal restoration. Information developed will be used to guide future estuarine restoration efforts throughout the Pacific nrthwest.

Common Issues and Outreach

Restoration of tidal wetlands during the WTRP will provide an informative example of cooperative wetland conservation, restoration, and management in the Pacific northwest. The South Slough NERR is managed as an estuarine nature preserve and special-use area that is set aside for research and education. South Slough NERR is operated as a partnership between the Oregon Division of State Lands (ODSL) and the National Oceanic and Atmospheric Administration/Sanctuaries and Reserves Division (NOAA/SRD). Successful implementation of the WTRP and identification of effective techniques to accelerate recovery of estuarine habitats and functions will aid in the campaign to restore degraded estuarine tidelands throughout the Pacific northwest.

Rumrill is a Research Scientist and South Slough NERR Research Program Coordinator; Cornu is a Wetland Planner with the Oregon Division of State Lands/South Slough NERR.

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Al Lovaas: 1953-1993 – A Professional Obituary

By Ross Kavanagh

In April of this year the NPS Alaska Region lost, through retirement, a highly valued employee, a hardy stump of a Regional Chief Scientist/Chief, Natural Resources Division with deep roots in the fields of wildlife management and ecological research. Though professionally dead, Al Lovaas, with his less cranky half, Nancy, is physically alive, well, and well watered in his new home in Hot Springs, SD, and is even said to be growing a few inches.

His long and distinguished 40-year career is worth at least a brief review: 1953–Graduated SD State U, BS in wildlife management; 1953-55–U.S. Army, tour in Germany; 1957–Graduated MT State U, MS in wildlife management; 1957-59, Wildlife Biologist, MT Dept. of Fish and Game; 1960-61–Mammalogist, Canadian Wildlife Serv., Edmonton, Alberta; 1962-63–Research Biologist, MT Dept. of Fish and Game, Gallatin Canyon, working on joint elk project funded by USFS, NPS, and MT Dpt of F&G; 1964-65–District Game Manager, MT Dpt of F&G, Great Falls, MT; 1966-70–Regional Biologist, NPS Midwest Reg., Omaha, NE; 1970-75–Research Biologist, Wind Cave NP, SD; 1975-80–Regional Chief Scientist, NPS Midwest Region, Omaha; 1981-93–Regional Chief Scientist/Chief, Natural Resources Div., NPS Alaska Region, Anchorage.

Al was a popular employee in the Alaska Region and won a certain renown as an occasional writer for Park Science. Whenever he had an article printed in Park Science, the editor could always look forward to frantic letters to the editor immediately afterwards.

Al never aspired to every new-fangled computer contraption for his personal office. He was often found, pencil poised over yellow legal pad, solemnly regarding his electric pencil sharpener as the epitome of high technology. (He was often heard to say "Computers are but a passing fad.")

What He Stood For

Al was particularly interested in improving human resource management within the NPS. He was a strong advocate of professionalism, including the creation, upgrading, and/or redescription of professional resource management/research positions, and revision of selection criteria and prerequisite training for new superintendents and other new top NPS managers. In effect, Al championed change within the NPS.

Letter from Lovaas

August 4, 1993

...Would you believe I haven't garnered even one eagle yet? Only a couple of birds...but sure lots of bogies and double (and higher) bogies, plus a few pars. My excuse is I hardly golfed at all during my 12 Alaskan years. Have bought a sailboat and ordered a new outboard for my Boston Whaler fishing boat. I'm finding that playing is almost as much work as working!

I've fallen in with some evil 70-year-old companions and we golf every weekday morning. Yesterday I lost 70 cents but today I made 40 cents. Got to start keeping track for IRS purposes. Course, today I paid for the coffee (30 cents).

(Excerpt from a letter to the editor.)

A man with high, positive standards always has similarly strong dislikes and Al was no exception.

His Gripes

Employee attitudes were important to him. His pet peeve, at least in the early days of post-ANILCA (Alaska National Interest Lands Conservation Act) Alaska, was NPS employees who ignored mandates of Congress because they didn't agree with them. These employees felt that sport hunting in Alaskan preserves and subsistence hunting in new Alaskan parks, preserves, and monuments was inappropriate and that hunters were less than highly valued visitors to NPS-managed lands. He felt that those NPS employees should try to change the law and transfer to areas where hunting is prohibited, but should willingly carry out congressional mandates. To him, that was the mark of a true professional.

His Pleasures and Irritations

While in Alaska, a point of satisfaction for Al was his role in solidifying relationships with the Alaska Department of Fish and Game. In addition, he was most proud of the world-class wolf and caribou research done by Layne Adams and crew (begun by Frank Singer), an ambitious effort to elucidate the workings of a truly natural ecosystem.

Al felt that better understanding of these workings can have immense implications for NPS resource management everywhere, with wolves present or in their absence, often for many years. To have some NPS employees scoff at the value of such research and oppose its long-term funding was personally irritating–even demoralizing to him. Al argued that as predators at the top of the food chain, wolves directly or indirectly affect entire ecosystems, including vegetation, soil, water, fish, and birds as well as their mammalian prey species.

His Integrity

Al will be sorely missed in the Alaska Region (for at least a year or two). He once commented to me that a past Regional Director told him he could always be counted upon for totally honest advice and recommendations uncolored by what he thought the Regional Director wanted to hear. To me, that statement best describes Al and his professional career, and has since become one of the key standards I strive to apply to my own career.

Although he received letters of appreciation during his career, interestingly enough Al, with his direct, sometimes blunt approach, never received any special awards or financial bonuses from management during his 28 year sojourn with the NPS. Those who know him well do not wonder why.

Have a great retirement Al, and we all wish you the best!

Kavanagh is Regional Fishery Biologist at the Alaska Regional Office.

Andrew Blaustein and Deanna Olson (of the U.S. Forest Service) conducting their yearly census of toads in the central Cascade Range of Oregon.

Declining Amphibian Populations in Perspective

By Andrew R. Blaustein

The National Science Board (1989) recently concluded that an ongoing and unprecedented loss of the variety and numbers of species around the world exists. Indeed, members of all taxa are affected. As part of this overall "biodiversity crisis" there have been numerous recent reports suggesting that the populations of amphibian species in a wide array of geographic regions and habitats apparently have declined or have experienced range reductions (e.g. reviewed by Barinaga 1990; Blaustein and Wake 1990; Phillips 1990).

Disappearance of frogs, toads, and salamanders have been reported on all continents where amphibians are found. Some species have become extremely rare and others recently may have gone extinct. For example, the golden toad (*Bufo periglenes*) from Costa Rica was abundant as recently as 1987 and has become extremely rare since then (Crump et al. 1992). The gastric brooding frog (*Rheobatrachus silus*) from Australia has not been seen since 1979 (Tyler 1991).

However, not all amphibian species are in decline and there are species whose populations seem to be persistent in the same areas where populations are declining. Moreover, most of the reports on declining amphibian populations are based primarily on anecdotal information. The lack of long-term data regarding amphibian populations makes it difficult to assess the overall significance of these reports. Below, I briefly summarize some of the major issues concerning the amphibian decline problem.

Ecological Importance of Amphibians

Amphibians are integral components of many ecosystems and they may constitute the highest fraction of vertebrate biomass in certain ecosystems (e.g. Burton and Likens 1975). Because of the important contribution of amphibians to trophic dynamics in a variety of communities, a decline in their numbers could have important impacts on other organisms. Adult amphibians play major carnivore roles in many systems and serve as prey in others (Duellman and Trueb 1986); larval amphibians can be important

predators and herbivores as well as prey (Duellman and Trueb 1986) in aquatic habitats.

Moreover, amphibians may serve as good bioindicators of environmental stress (1) due to their permeable skin that readily absorbs toxic substances, (2) because they are not protected by hair or feathers, (3) because their eggs are not encased in hard shells, and (4) because many species may come in contact with both terrestrial and aquatic stresses due to their complex life cycles.

Long-term Studies

There have been few studies where amphibian populations were sampled at least once per year on a long-term basis. Of those long-term studies that have been conducted, some show populations that are in decline, whizle others do not. Two long-term studies from Europe have documented declines. Semb-Johansson's (1989) study of common toads (*Bufo bufo*) on islands off the Norwegian coast is one of the best examples of a long-term population study of an amphibian. Toads were monitored for 24 years (1966 to 1989). Their numbers declined dramatically from 1966-1975 and have remained low. Beebee et al. (1990) have documented the decline of the natterjack toad (*Bufo calimata*) in Great Britain over a 20 year period.

Studies in the U.S. show different population dynamics in different regions. Corn and Fogleman's (1984) study documented the local extinction of leopard frogs (*Rana pipiens*) in Colorado across a number of sites. In this study, six populations of *R. pipiens* were examined for 10 years (1973-1982). Reproductive failure was seen in 1973 at one site and by 1981 no *R. pipiens* were seen at any site. *Rana pipiens* was absent from the area at the end of the study.

Kagarise Sherman and Morton (1993) documented the population changes over 20 years in *Bufo canorus* at Tioga Pass, California. Comprehensive surveys of breeding aggregations were made from 1971-1982 and less systematic observations were taken from 1983 to 1991 at Tioga Pass. Six additional populations in northern Calfornia also were monitored from 1973-1990. At the largest breeding pools at Tioga Pass, the populations declined about 9-fold from 1974-1982. The mean number of toads found in daily searches also declined during the 20 year period. Similar declines at the other sites were reported.

A 14 year study by Jaeger (1980) in Virginia suggests that the Shenandoah salamander (*Plethodon shenandoah*) has been declining probably due to competition with *P. cinereus* whose populations are relatively rare.

Pechmann et al. (1991) monitored the breeding population sizes of four amphibian species at one site in South Carolina for 12 years. They showed that the populations of three species fluctuated and one species increased over that time span.

In addition to the subjects of the the long-term studies cited above, populations of other amphibian species have disappeared from portions of their historical ranges (without concomitant shifts in their ranges) and have failed to reestablish at such sites for periods longer than their estimated maximum life span. For example, this has occurred in several species in western North America, including the Cascades (*Rana cascadae*), Red-legged (*R. aurora*), and western-spotted (*R. pretiosa*) frogs and the western toad (*Bufo boreas*). In addition, the eggs of several of these species have experienced unusually high mortality in recent years (Blaustein et al. 1993). In the same region as these species, populations of the Pacific treefrog (*Hyla regilla*) seem to be persistent.

Causes

Habitat destruction and habitat alteration probably are the major causes for decline in amphibian populations. However, due to lack of long-term data it is difficult to distinguish between human-induced causes and natural population fluctuations. For example, very little is known about the population dynamics of golden toads and gastric brooding frogs, so it is possible they may be in dormancy and may again be common when conditions are better.

The author (Andrew Blaustein) holding a device that filters out ultraviolet light. The filters are placed over developing eggs in experiments investigating the role of ultraviolet radiation on amphiban declines.

Besides overt habitat destruction and natural population fluctuations, other proposed causes include introduction of exotic species such as fish and bullfrogs, disease, ultraviolet radiation, and acidification. Most of these hypothetical explanations have not been examined experimentally.

In the Pacific Northwest, where there have been range reductions in a number of species, unusual egg mortality, and disappearances of large numbers of tadpoles, we are continuing to accumulate long-term population data at a variety of sites for a number of species. We also are investigating the role of pathogens and ultraviolet radiation in the declines of several species of amphibians from Oregon.

Blaustein is a professor in the Department of Zoology, Oregon State University, Corvallis, and co-chair of the Pacific Northwest section of the IUCN's Declining Amphibian Populations Task Force.

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Status of Amphibians in Arizona

By Cecil R. Schwalbe

As in many other parts of the world, Arizona has seen declines in populations of some of its amphibians. And as Andy Blaustein indicates, lack of long-term data makes it difficult to differentiate human-induced causes from natural population cycles. Native ranid frogs [specifically the Tarahumara frog (*Rana tarahumarae*), northern leopard (*R. pipiens*), and Chiricahua leopard (*R. chiricahuensis*) frogs] seem to have suffered greater declines than other frog and toad species (Hale and Jarchow 1988, Clarkson and Rorabaugh 1989).

The last Tarhumara frogs seen in the United States were found dead in the Santa Rita Mountains in 1983. Populations of Chiricahua and lowland (*R. vavapaiensis*) leopard frogs cohabiting with Tarahumara frogs also declined but were not extirpated; canyon tree frogs (*Hyla arenicolor*) and red-spotted toads (*Bufo punctatus*) living there seemed unaffected by whatever caused the ranid reductions (Hale and Jarchow 1988).

While there is concern that the numbers of individuals in some breeding aggregations of desert anurans such as Sonoran green (*Bufo retiformis*), Sonoran Desert (*B. alvarius*), and Great Plains (*B. cognatus*) toads, burrowing tree frogs (*Pternohyla fodiens*), and desert spadefoots (*Scaphiopus couchi*) have declined, large numbers of local extirpations have not been documented. Long-term monitoring programs are needed, for both anurans and tiger salamanders, Arizona's only tailed amphibian.

Wetland habitat loss and degradation probably are responsible for most declines and extirpations of historical anuran populations in Arizona; however, conclusive data are lacking. Declines in some frog populations have been correlated with the introduction of exotic predators such as game fish, bullfrogs, and crayfish (Hayes and Jennings 1986, Schwalbe and Rosen 1988, Schwalbe and Rosen unpublished data). We also are testing the interaction of pathogens and ultraviolet light on some anurans, (suspected causes in the extirpation of the Tarahumara frog from the U.S.). Our preliminary data indicate that the true frogs (family Ranidae) may prove to be the most sensitive vertebrate indicators of air quality.

Because of the scarcity and fragility of wetlands in the desert Southwest, resource managers here are concerned about the health of these wetland ecosystems. The AZ Game and Fish Dept., AZ Nature Conservancy, NPS, USFWS, and USFS are conducting surveys of and working to establish monitoring programs for wetland biota, including amphibians, in Arizona. Cooperative research and management programs also are being pursued between agencies and institutions in the U.S. and in Mexico for sensitive wetlands and their components. Long-term studies of populations, coupled with directed experimental research, are necessary if we are to separate out human-induced causes of declines from normal population fluctuations.

Schwalbe is a Research Ecologist with the NPS Cooperative Park Studies Unit (CPSU) at U/AZ.

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Amphibian Decline on the Colorado Plateau

The Cooperative Park Studies Unit at Northern Arizona University (CPSU/NAU) is collecting information to help address the question of amphibian decline on the Colorado Plateau. CPSU biologists are conducting inventory and assessment of reptile and amphibian communities at Montezuma Castle National Monument (MOCA) and a survey of leopard frogs in Glen Canyon NRA (GLCA). They are compiling these data in conjunction with information previously obtained by the CPSU on historical occurrence of these species in other Colorado Plateau national parks and monuments.

The CPSU survey of the herpetofaunal community at MOCA began in December 1992, and is part of the NPS Natural Resources Protection and Preservation Program. Sso far, three amphibian species have been found; two appear to have stable breeding populations: Woodhouse's toad (*Bufo woodhousei*) and Canyon treefrog (*Hyla arenicolor*). The third species is the non-native bullfrog (*Rana catesbeiana*). The impact of these introduced predators on the local amphibian community is not yet known.

Continued on page 11

Sonoran Desert Tortoise. (*Photo by Cecil Schwalbe*)

Amphibian continued from page 10

Nine additional amphibian species have occurred in the Verde Valley historically or have ranges that include MOCA but have not yet been found. Of these, (the tiger salamander, Southwestern toad, Great Plains toad, red-spotted-toad, Sonoran Desert toad, Southern Spadefoot, possibly Northern leopard frog, Lowland leopard frog, and the Chiricahua leopard frog), the Chiricahua frog and the tiger salamander are listed by Arizona as threatened species and the Northern leopard frog is a candidate species for listing.

The CPSU also is conducting a leopard frog survey in GLCA along the Colorado River corridor below Glen Canyon dam. Leopard frogs first were found in this area in 1992 by GLCA Resource Management Division and CPSU/NAU staff. In a follow-up survey in early June 1993, biologists from these units found an isolated but stable breeding population of Northern leopard frogs, located in a natural spring and run-off area not contiguous with the Colorado River under existing water flow regimens from the dam. The water in the breeding pools is warmer than that of the adjacent river, and no predatory fish were found. These factors undoubtedly have allowed this leopard frog population to remain healthy despite dramatic changes in temperature and flow of the Colorado River. No satellite populations of dispersed leopard frogs have been found to date, but an additional survey will be conducted later this year.

The CPSU will continue efforts to gather information on amphibian populations on the Colorado Plateau, including analysis of existing information in park inventory and monitoring databases, and coordination with other agencies, including the two regional working groups of the IUCN/SSC's Declining Amphibian Populations Task Force.

CPSU biologists will continue the Montezuma Castle inventory and monitoring program until 1995; will conduct additional surveys for leopard frogs in the Grand Canyon area; and will be compiling information on the historical distribution of regional amphibian species. The CPSU welcomes any information about amphibian populations on the Colorado Plateau and in return will provide information and assistance for implementation of I&M programs to interested managers.

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Can We Afford Biodiversity?

In view of the National Park Service's preservation mandate, the question of whether or not we can afford biodiversity may appear to be rhetorical. But as scientists learn more and more about the habitat requirements of the myriad species still extant in North America, the cost of maintaining species richness–beginning today and extending into the unforeseeable future–mounts to confounding proportions. Mounting political resistance and shrinking preservation budgets may have a lot to do with how the emerging controversy plays itself out.

The June 25, 1993 issue of *Science* devotes its News & Comment section to a piece entitled "The High Cost of Biodiversity." Its authors, Charles C. Mann and Mark L. Plummer, describe the plan to protect North American biodiversity that emerged from the seventh annual meeting of the Society for Conservation Biology, held June 11 at Arizona State University in Tempe. This dramatic proposal, labeled the Wildlands Project, calls for nothing less than the resettling of the entire continent–"the most ambitious proposal for land management since the Louisiana Purchase of 1803."

Even the dedicated faithful ("a mix of Oxford cloth and Birkenstocks, with a preponderance of male facial hair") greeted the design with gasps. It calls for a network of wilderness reserves, human buffer zones, and wildlife corridors stretching across hundreds of millions of acres--as much as half of the continent. The long-term goal of the Wildlands Project is the transformation of the United States "from a place where 4.7% of the land is wilderness to an archipelago of human-inhabited islands surrounded by natural areas."

Ecologist Reed F. Noss, editor of *Conservation Biology* and one of the plan's architects, called it "a vision of what this continent might look like in 200 years if we can reduce the scale of human acitivities."

Wild as the notion may seem, Mann and Plummer report that the principles behind it have been endorsed by scientists of stature including Edward O. Wilson of Harvard, Paul Ehrlich of Stanford, and Michael Soule of the University of California, Santa Cruz, who view the approach as the logical follow-up to the reserve design underlying the proposed Northwest spotted owl reserves. One prominent ecologist who asked not to be named acknowledged that the plan "seems nuts," but added that when you think about it, it is more or less where the science is pointing.

The color maps that accompany the *Science* article show how the plan would affect coastal Oregon and Florida. Color coding shows core areas, corridors, and buffer zones that would protect not just spotted owls (in Oregon) and panthers (in Florida) but a host of other species–from charismatic to microscopic.

The article explores the controversy surrounding the concept of corridors, questioning their efficacy on the one hand (data is scanty as to their actual use) and proposing on the other hand that relatively little use "may be enough" if one or two individuals a decade manage to migrate and add new genes to a stagnant pool.

NPS ecologist Craig Shafer, author of **Nature Reserves: Island Theory and Conservation Practice**, is quoted as having some doubts about the numbers on which the Wildlands plan is based, but as contending that the whole package–core reserves, buffer zones, and corridors–is needed for complete protection. "For every line of analysis," Shaffer said, "the weather vane is pointing in the same direction ... toward needing a network in the landscape."

Deborah Jensen, the Nature Consevancy's director of conservation science, commented "drily" that "this whole business about wildness being fierce is a male thing" and disagreed with the plan's decision to begin with present wilderness areas ("often species-poor") instead of focussing on areas of maximum biodiversity and preserving those first. Mann and Plummer spent one paragraph alluding to the hue and cry that would inevitably go up if the plan were to be sprung as a whole on the political scene. Dave Redmond, press secretary to Rep. Bob Smith (R-Or), who has introduced legislation to scale back the Endangered Species Act, warned that "the people who would be impacted by such reserves are absolutely terrified by them." Politically, Redmond said, the plan "is just undoable." If such a plan is the only way to preserve biodiversity, then said Redmond, some biodiversity will have to go. "That is what we are facing."

Jean Matthews, *Editor*

Paleoecology of Late Triassic Metoposaurid Amphibians: Evidence from Petrified Forest National Park

By Adrian P. Hunt, Vincent L. Santucci and William P. Wall

The Late Triassic (235 to 208 million years ago) was a time of major change in the terrestrial ecosystem. Archaic animals, that had dominated the land during the Late Paleozoic and earlier Triassic (e.g. therapsids, temnospondyls), dwindled or became extinct and the major groups preeminent in the later Mesozoic and Tertiary (e.g. dinosaurs, mammals, pterosaurs) evolved and diversified. In North America, the last of the temnospondyl amphibians are members of the family Metoposauridae (Figure 1). The paleoecology of this family has received little study.

One of the best places to study the paleoecology of metoposaurids is at Petrified Forest NP (PEFO). Abundant specimens collected in the park can be studied to determine the paleoecological context of these ancient amphibians. Metoposaurids at PEFO are found in the Blue Mesa (lower) and the Painted Desert (upper) members of the Petrified Forest Formation.

Buettneria perfecta is a large species (2 meters long) with deep otic notches, a lacrimal that borders the orbit and short intercentra. *Apachesaurus gregorii* is a small species (less than 1 meter long) with shallow otic notches and elongate intercentra. *Buettneria* is common in the lower stratigraphic sections of the park and becomes rarer in the upper member, whereas *Apachesaurus* is rare in the lower member and is relatively more common in the upper member.

Paleoecologic information regarding the Late Triassic metoposaurs is derived from three primary sources: sedimentology of the deposits in which metoposaurs are preserved; morphological characteristics; and taphonomic associations with other fossil remains. Evaluation of the data available from these three sources suggest that *Apachesaurus* probably was more terrestrial than *Buettneria.*

The sedimentary deposits containing *Apachesaurus* vary considerably from those sediments in which *Buettneria* remains are preserved. *Buettneria* occurs predominately in near stream facies. Those depositional environments include fluvial overbank and lacustrine deposits. *Apachesaurus* occurs frequently in more terrestrial sediments formed as distal floodplain deposits. Paleosol (fossil soil) analysis provides supporting data associating wetter near-stream facies and drier terrestrial facies.

Comparing the morphology of these two metoposaurs reveals a number of differences that indicate *Apachesaurus* was more terrestrial than *Buettneria.* First, the deeper acetabulum (pelvis) of *Apachesaurus* provided a more effective transmission of hindlimb force, which is important for terrestrial locomotion. Second, the vertebrae of *Apachesaurus* are elongate compared to other metoposaurs. This elongation, coupled with a possible reduction in number of vertebrae, would have given this animal a rigid backbone. This pattern is characteristic of terrestrial vertebrates where weight support is necessary. Third, the lateral line system (pressure receptors sensitive to vibrations in water) is reduced in *Apachesaurus* compared to *Beuttneria.* Cranial and dental characteristics, however, indicate that *Apachesaurus* probably was an aquatic feeder. The low cranial profile is suited to rapid jaw closure, but the jaw muscles could not have generated much force after closure. This feeding pattern is characteristic of fish-eaters. Homodont dentition, as seen in *Apachesaurus* and other metoposaurs, also is commonly associated with fish-eating.

The taphonomic associations which co-occur with *Buettneria* are predominantly composed of semiaquatic and aquatic fauna (phytosaurs, lungfish). *Apachesaurus* often is found in association with more terrestrial assemblages of vertebrates (dinosaurs, rauisuchians, sphenosuchians). These associated fossil forms provide additional information on the paleoecology of these ancient amphibians.

The Petrified Forest metoposaurs provide useful information for interpreting the Late Triassic environment in this region. The oldest strata in the park were laid down during wet periods resulting in larger lacustrine and fluvial systems. This environment provided *Buettneria* with suitable open water habitat to accommodate a highly aquatic, large-size amphibian. The younger strata in the park indicate a drier environment with more restricted shallow pools of water. The morphological characteristics of *Apachesaurus* were better adapted for movement over land in this drier and more patchy environment.

Hunt is a professor of geology at UICO, Denver; Santucci is a paleontologist and curator at Petrified Forest NP; Wall is a professor of biology at Georgia College, Milledgeville, GA.

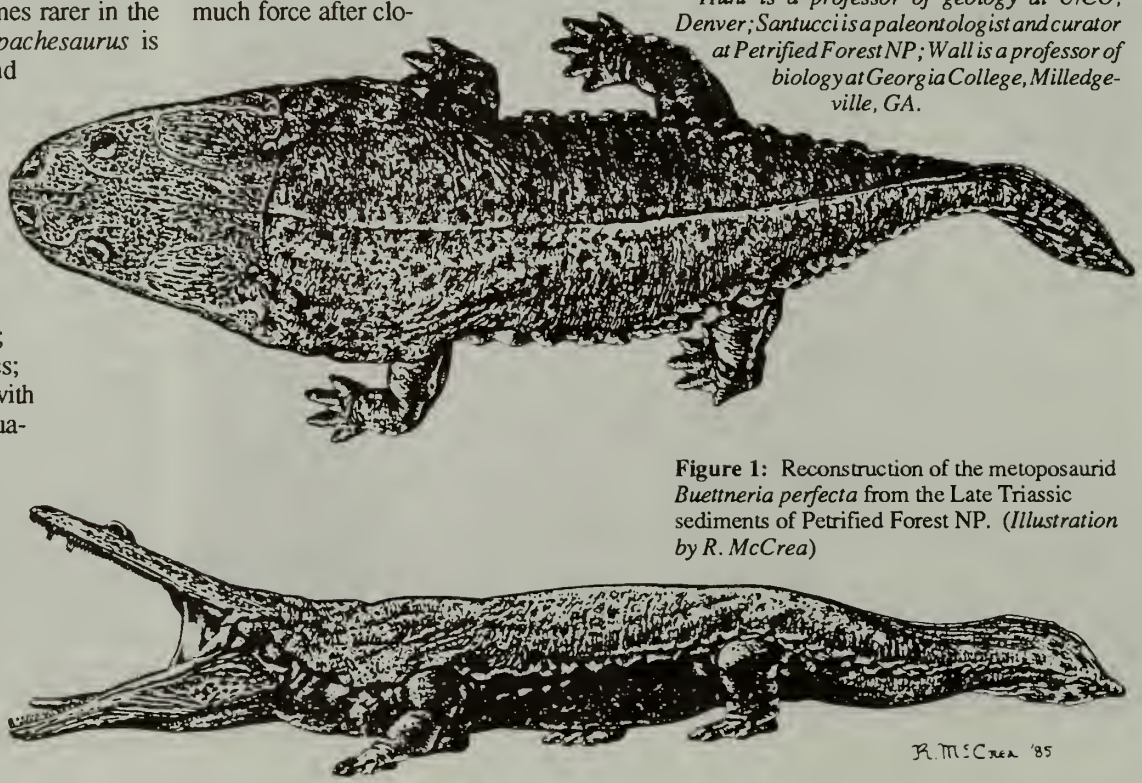

Figure 1: Reconstruction of the metoposaurid *Buettneria perfecta* from the Late Triassic sediments of Petrified Forest NP. *(Illustration by R. McCrea)*

New Fossil Mammals Found at Florissant Fossil Beds NM

By Emmett Evanoff and Peter M. de Toledo

New discoveries of fossil mammals in Florissant Fossil Beds National Monument (NM) indicate that the Florissant Formation is late Eocene in age, and correlates with the Chadrom Formation in Badlands NP.

Fossil mammals are rare in the Florissant Formation and have been somewhat ambiguous age indicators. Previous to the recent discoveries, mammals from the Florissant Formation have included oreodons (*Merycoidodon*), a horse (*Mesohippus*), a mouse opossum (*Peratherium*), and an unidentified rhinoceros. Of these specimens, only the mouse opossum (*Peratherium* near *P. huntii* (Cope)) has been described in detail (Gasin, 1935). These mammals indicate a Chadronian or Orellan North American Land Mammal Age for the formation. The Chadronian and Orellan are now considered to be latest Eocene and earliest Oligocene age, respectively.

In June and July of 1992, a field crew from the University of Colorado Museum found fossil mammal bones, including a piece of a neck vertebra from a large brontothere, a lower jaw of a *Mesohippus* (Fig. 1), bone fragments from an oreodon-sized animal, and bone fragments and isolated teeth from a small artiodactyl. These fossils occurred in sandstones lateral to the main lake shales and fluvial mudstones below the level of the fossil stumps.

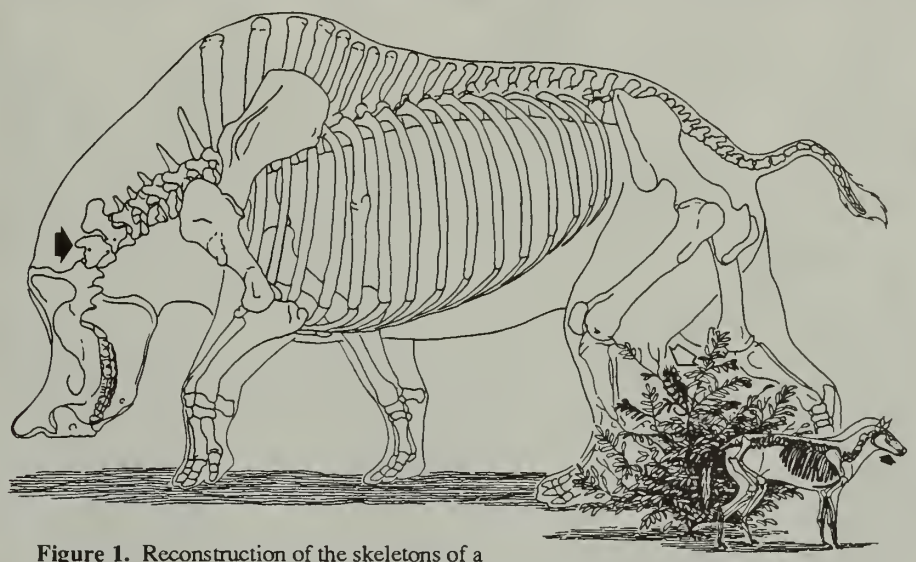

Figure 1. Reconstruction of the skeletons of a brontothere and the horse, *Mesohippus*, showing the bone elements found in the summer of 1992 (arrows) at Florissant Fossil Beds National Monument. Also shown is a mouse opossum in the bush (open arrow). The skeletons are drawn to the same scale, with the bush representing a height of 1 meter.

The co-occurrence of a brontothere, *Mesohippus*, and *Merycoidodon* indicates that the Florissant Formation was deposited at the same time as the Chadron Formation of Badlands NP. The Florissant vertebrate fauna also include fossils of fish and birds, and together they may supplement paleoenvironmental data provided by the plant and insect fossils.

Evanoff and de Toledo are with the University of Colorado Museum, Boulder, CO, 80309-0315.

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5th Wilderness Conference Addresses Changing Picture

The 5th Annual Interagency Wilderness Conference was held May 17-21 in Tucson, AZ, with 268 persons from NPS, FWS, BLM, USFS, and numerous universities, attending. The program addressed three major themes: (1) Wilderness Restoration: Use of minimum tools in revegetation, (2) Managing Wilderness, Cultural Resources, and Cultural Diversity, and (3) Emerging Challenges: Adjacent land uses, day use, outfitters, and access for the disabled.

A pair of plenary speakers addressed each theme. Thought and dialogue about wilderness restoration focused on the minimum tools necessary to accomplish reintroduction of extirpated plants and removal of alien species. The need for and lack of comprehensive inventory and monitoring efforts in daily wilderness management programs surfaced repeatedly. One of the most widely-attended sessions depicted the strong role trail maintenance staff can have in revegation activities, as well as reducing original losses of vegetative cover and soil.

Gary Machlis, (CPSU/U/ID) asserted that viability of the wilderness concept may wane as demographic, social, and political change sweeps the country. This was underscored by Hal Salwasser (U/MT-Missoula), who predicted that wilderness managers who view their role as merely stewards of dynamic ecosystems may be overlooking important actions necessary to manage or restore spiritual, religious, economic, subsistence, social, or cultural values.

A conference handbook with the 70+ papers presented is available upon request from Resource Management Specialist/Wilderness Forester Alan Schmierer via FAX 415-744-3932 or cc:mail.

Alan Schmierer,
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This five-toed track produced by a small lizard-like animal was among the first of the vertebrate tracks to be discovered in the park.

Late Triassic Vertebrate Tracks Discovered at Petrified Forest NP

By Vincent L. Santucci and Adrian Hunt

Fossilized tracks of Late Triassic reptiles were discovered in April 1993 at Petrified Forest NP. Although paleontological field work has been conducted in the Chinle Group of Arizona since the turn of the century, these are the first fossil vertebrate tracks discovered. The presence of fossil tracks in association with fossilized bone brings us closer to identifying tracks with track-makers.

Two different track types have been identified in 220-million year old channel sandstone blocks. The sandstone unit represents a shallow stream with episodic flow that meandered across a broad plain. Tiny five-toed tracks called *Rhynchosauroides*, produced by a small, lizard-like animal, were the first vertebrate tracks to be discovered in the park. This fossil vertebrate track type is known from rocks in New Mexico, Utah, and Colorado. A swimming trace of a larger reptile, possibly a phytosaur, was located during a secondary survey. This trace preserves scrape marks where the reptile claws scratched the substrate.

Fossil invertebrate tracks, trails, burrows, and other traces are abundant within the park. A type specimen of horseshoe crab track, (*Kouphichnium arizonae*), was described in 1944 by Kenneth Caster. Steve Hasiotis, a graduate student at the University of Colorado at Boulder, is involved with a comprehensive survey of the park's ichnofossils (trace fossils). Steve recently collected and described the earlist known fossil termite nest from the Petrified Forest Formation in the park.

The importance of trace fossils and their identification has increased dramatically over the last two decades. Trace fossils have been reported from many National Park Service units. In addition to these found at Petrified Forest NP, vertebrate tracks occur at Arches NP, Badlands NP, Canyonlands NP, Colorado NM, Death Valley NM, Dinosaur NM, Glen Canyon NRA, Grand Canyon NP, Montezuma's Castle NM, Pipe Spring NM, and Zion NP. There is even a stone bridge at Gettysburg NBP that has a dinosaur track in one of the quarried blocks.

Recently it has been recognized that vertebrate tracks are not randomly distributed throughout Late Triassic rocks of the western United States. Most tracks are in the uppermost (youngest) strata of this age (e.g., Dinosaur NM, Canyonlands NP, Colorado NM). The tracks at Petrified Forest NP are several million years older than the other known Late Triassic tracksites in the western U.S. The high density of associated skeletal remains in the park produces a rare opportunity to correlate the track with the track-maker.

Santucci is Paleontologist/Curator at Petrified Forest NP; Hunt is a Vertebrate Paleontologist (and caffeine junkie) with the Dept. of Geology, U/CO at Denver.

Book Review

By Ed Starkey

Every now and then I stumble onto a book about which I become so enthusiastic that my friends suspect that I own stock in the publishing company. **Extinction: Bad Genes or Bad Luck?** by David M. Raup (W.W. Norton, 1991) is such a book.

Although, for many of us, a book on paleontology may not seem to be a likely choice for recreational reading, this book is fun to read. Raup makes a potentially dull subject exciting, partially at least with irreverence. Stephen Jay Gould writes in the Introduction that if Raup "has any motto, it can only be; Think the unthinkable (and then make a mathematical model to show how it might work); take an outrageous idea with a limited sphere of validity and see if it might not be extendable to explain everything".

Raup's emphasis throughout the book is on extinction. His main question is "whether the billions of species that died in the geologic past died because they were less fit (bad genes) or merely because they were in the wrong place at the wrong time (bad luck)." He concludes that extinction is a combination of bad genes and bad luck. Some species die out because they cannot compete or cope in their normal habitat, but "most species die-out because they are unlucky. They die because they are subjected to biological or physical stresses not anticipated in their prior evolution and because time is not available for Darwinian natural selection to help them adapt."

Raup explores the likelihood that meteorite impact has been the primary cause of species extinctions detected in fossil records, ie. the source of "bad luck" and unanticipated biological or physical stress. Both sides of the issue are discussed, but after reading the book it is hard for me to dismiss meteor impact as a likely cause of extinctions. He really got my attention with the suggestion that the risk of a "civilization destroying" impact during a human lifetime might be 1:4,000.

Raup further suggests that extinction through bad luck does not challenge Darwin's natural selection. He believes that natural selection remains the best explanation for sophisticated adaptations such as eyes and wings, and that we would not be here without natural selection. His view is that extinction by bad luck only adds another element to the evolutionary process, operat-

Continued on page 15

Book Review

Ecology and Our Endangered Life-Support Systems, by Eugene P. Odum, from The Institute of Ecology, The University of Georgia. Published by Sinauer Associates, Inc. Publishers, Sunderland, Massachusetts. Second Edition. 301 pp. ($18.95 at the Northern Arizona University bookstore).

In this refreshing and very readable paperback book, aptly titled *Ecology and Our Endangered Life-support Systems*, Eugene P. Odum unfolds and lays out his concepts of Ecology. The principal theme of the book, (and which is now one of the 'hot' topics of ecology), is that of integrating the relationships between individual organisms, the physical environment, and human society.

The basic preceptsare biological, but someone only vaguely familiar with biological terms and definitions could easily pick up this book and read, enjoy, and profit from it. Using the concepts of life support systems, first introduced in the Prologue by a detailed description of the flight and life support systems of Apollo 13 (the spacecraft crippled by an explosion in 1970), the reader is carried on a journey to understand how the earth is composed of interlocking and interacting systems that holistically add up to mankind's 'life-support.' The developed, cultivated, and natural aspects of the landscape must interact to support life as we know it now and in the future. Odum shows how these systems exist at a variety of levels, from individuals through populations and communities to the biosphere on a global scale, and how they interact synergistically.

Interestingly, one of the major components Odum inserts into the ecological picture is economics, a theme carried throughout this book. He feels that the interface between ecology and economics is so strong that the human population problem is probably economic, or perhaps political (but he does not emphasize any biological role). His often repeated reason for the degradation of species and their environments are economic pressures. Likewise, his solution for protecting species and their environs is economics. This concept will be an ever increasingly important one for land managers trying to deal with the impact of land development contiguous to (and within) their managed lands.

Energy is addressed as a common denominator of life on earth linking ecosystems to economics. When a problem occurs—and many problems are pointed out—Odum insists that there is no quick fix. All three components (ecology, economics, energy) must be considered if any degree of long term success is to be expected. An example of one idea is to use energy as a basis for evaluating so called 'worthless land' in terms of energy produced for the biosphere upon which we all are dependent. For example, under this system one acre of tidal estuary becomes worth $20,000 to $50,000. Our real cost of living is not always accounted for in terms of money. This gap in our decision making process needs to be closed before the proper values can be placed on our survival in the ecological world.

However, all the basics of Ecology are also contained within this book —i.e., the food webs, energy systems, ecosystems. But what separates this work from other ecology texts is its slant to human influence. Many examples come from the impact of farming and industry, yielding a refreshing blend of scientific concepts and a dose of the real world.

These examples and others throughout the book are presented clearly in diagrams and then the same symbols are consistently used throughout the book. Therefore, all diagrams are simplistic and easily understood with consistently labeled inputs and feed-back loops. Reference is made to widely read magazines such as *Time*, and at the end of the chapters are excellent references with some notes inserted by the author.

A recurrent theme in the book is the contention that narrow economic theories and policies dominating world politics are major obstacles to achieving balance of non-market and market goods and services. Odum contends that the 1992 Earth Summit, while producing few meaningful agreements, may have opened pathways for future cooperation among nations and therefore some hope for the future.In the epilogue he states three certainties as predictions for the future: 1. human beings will continue to increase in numbers; 2. We need to do something about the fouling of our life support systems; and 3. Humanity will make a major and painful transition in energy use as fossil fuels decrease. If we could summarize the essence of this book in one statement it would be that: only when ecology and economics can be merged, and ethics extended to include environmental as well as human values, can we be optimistic for the future of mankind.

For someone wanting a purely biological, "hardcore" scientific approach to ecology, this book will be disappointing. But, for an introduction to ecology and a balanced look at ecology as it is being influenced by mankind—this book is a great starting point. The book's major value lies in Odum's approach that man is not only part of the ecosystem and biosphere, but that he is a major factor and driving force and must take some responsibility for his influences. The material contained within, and the approaches used by this author, would be enlightening for anyone from park superintendent, to resource manager, to naturalist interacting with the public.

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Book Review continued from pate 14

ing at the level of species, families, and classes instead of at the level of breeding populations of individual species.

Because I have recently spent considerable time thinking about threatened and endangered species, Raup's perspectives on recent and ongoing extinctions were especially interesting. He suggests that "human activities provide the first strike necessary to reduce species' ranges so that extinction from other causes is likely. Thus, current concerns about endangered species are justified because the human species is producing first strikes regularly – first strikes that nature supplies only at intervals of millions of years."

As Malcolm W. Brown of the **New York Times Book Review** wrote, this book is "An eminently entertaining and informative read." I especially recommend the book to those interested in conservation biology and biodiversity issues. Raup challenges us to consider time-frames greater than those measured in human lifetimes, and to keep an open mind about causes of extinction.

Raup is the Sewell Avery Distinguished Service Professor and a statistical paleontologist at the University of Chicago. Other books by him include The Nemesis Affair, *also published by Norton.*

Starkey is Research Biologist at the NPS/ CPSU, OR State U.

Succession and Biological Invasion at Mesa Verde NP

By Lisa Floyd-Hanna, William Romme, Deborah Kendall, Allan Loy and Marilyn Colyer

In a study of plant succession following the 1989 Long Mesa burn in Mesa Verde National Park (MVNP), Colorado, we documented a rapid invasion and increase in exotic (non-native) weeds into areas subjected to hot fires. Although the 1,200 ha burn covered both mountain shrub (*Quercus gambelii* and *Amelanchier utahensis*) communities and well-developed pinon-juniper (*Pinus edulis* and *Juniperus osteosperma*) woodland, only the latter show prolific non-native plant invasion. These sites were characterized by high mortality and exposure of mineral soils, and now support dense stands of Musk thistle, *Carduus macrocephalus* (nutans).

We presently see no evidence that native species will replace Musk thistle in the 1989 Long Mesa Fire area. Rather, it appears that Musk thistle has preempted extensive areas in the burn, particularly those of high fire intensity, and that this very competitive species will dominate these sites for a very long time--perhaps indefinitely. This fear is nurtured by the persistence of stands of exotic thistles–both Musk and Canada (*Cirsium arvense* L. throughout La Plata and Montezuma counties since their invasion during the 1970s. Where the weeds are abundant, new pathways of succession may be in progress, pathways that never before have been documented and are largely unpredictable with our present knowledge.

Nature reserves are not immune to degradation by aggressive invader species. Indeed, nearly all reserves in the world today are troubled by invasive vascular plants (Mooney and Drake 1989). For instance, Kruger National Park in Africa had 6 non-native plant species in 1937, 43 in the 1950s, and >160 today (Soule 1990).

Why be concerned about invasion of exotic plant species in a national park like Mesa Verde? A major reason is that invasive species have the potential to displace native species and alter natural ecological processes. For example, cheatgrass (*Bromus tectorum*), an annual originally from Eurasia, now is well established throughout the intermountain region in North America, especially in areas disturbed by plowing or heavy grazing, but also in relatively undisturbed areas (Mack 1986). Once cheatgrass forms a dense stand, it alters the fire regime by creating a continuous, highly flammable fuel bed that can readily carry fire across large areas. The species composition and ecological functioning of steppe communities over much of the intermountain west have been altered by the invasion of this single exotic plant species.

An Ecological Irony

At MVNP, natural disturbances such as fires and gaps created by forest pathogens are common. Man has added to the native regime with roads, visitor facilities, and sewage plants, all necessary to maintain a highly visited park. There is deep irony here, and also a serious dilemma for managers of nature reserves. Recent research in ecology has shown clearly that disturbance is essential to maintain the natural components and processes of the communities and ecosystems we are trying to perpetuate in our national parks and other nature reserves (e.g. Pickett and White 1986). However, disturbance also promotes invasion and degradation of habitats if seed sources for potential invaders are close by (Hobbs and Huenneke 1992).

Look out below! Thistle head weevils are given a helping finger during their application to a field of musk thistles.

How are we to deal with this double-edged process of disturbance? One approach is to recognize that the native species are adapted to the disturbance regime that prevailed in pre-settlement times, i.e. to a particular frequency, intensity, and type(s) of disturbance. The strategy for maintaining native species, then, is to maintain this pre-settlement disturbance regime. In most of our parks and reserves, disturbance regimes and pools of species available have changed dramatically since pre-European settlement times (Hobbes and Huenneke 1992). Reserve managers need to identify and subsequently eliminate or ameliorate changes in disturbance regimes that are "beyond the evolutionary experience of the native biota" (Macdonald et al. 1989).

Natural Disturbances

What was the pre-settlement disturbance regime in MVNP? Research currently is underway to answer this question. We are attempting to determine, for example, the frequency and spatial extent of severe, stand-replacing fires in the pinon-juniper and mountain shrub communities, and the mechanisms by which the dominant species became re-established after fire. Such fires apparently were an important part of the pre-settlement environment of Mesa Verde and therefore should be allowed to continue in some form. Small fires occurred an average of 7.6 times per year between 1927 and 1976, and 13.7 times per year between 1976 and 1989. Large tracts burned in 1934, 1959, and 1972 and they were not invaded by exotic species (unless intentionally seeded with *Bromus inermis*).

The successional pattern changed dramatically with the 1989 Long Mesa fire. The southern sector of the burn supports prolific weedy invasion (the true extent of Musk thistle invasion requires immediate documentation), while the northern sector is dominated primarily by native perennial shrubs. The substantial gradient in post-fire successional patterns across the 1989 fire is alarming. It is clear that pre-fire community structure plays a role in directing subsequent succession. On the southern half of the burn, pinon-juniper woodlands had been destroyed, exposing mineral soils. In contrast, the northern, shrub dominated section was repopulated with sprouts from native perennials within the first year after the burn.

Throughout MVNP, fungal and insect pathogens have killed thousands of pinon pines, leaving patches in the forest that have been invaded by non-native plant species.

The most devastating infestation has come from the Black-root rot, *Verticicladiella wageneri*, which infests patches of pinon pines, killing trees of all ages. The largest invasion of Musk thistle coincided with Black-root invasion patches, although supporting thistle stands, are isolated from one another. However, should the patches become more extensive or common, they eventually may provide "corridors" for movement of weedy seeds.

Disturbances Related to Human Activities

In general, areas disturbed earlier this century and abandoned are free of weedy species. Disturbances that occurred since the mid 1970s or those that are continually disturbed support non-native plant species. Abandoned roadways are found throughout the park and date from the 1930s to the 1960s. Construction upgrades on the existing paved road that took place in 1983 may have directly introduced weedy species through the use of sewage sludge, as well as indirectly by creating open habitats. A pipeline originally built in 1946 to carry water from the "Chicken Creek" National Forest area into the water treatment facility at the park entrance is being replaced. It crosses the steep north-facing escarpment, and then runs south to the heavily used Chapin Mesa facilities. Both roadways and waterline construction serve as effective "corridors" that facilitate weedy dispersal in the park. (The first Musk thistle stands in Mesa Verde were on Chapin Mesa around 1980 following road construction activities that imported gravel from thistle-infested sites.)

Sewage facilities, constructed in 1963, 1965, and 1975, are located on Wetherill Mesa, Chapin Mesa, Far View, and Morefield Canyon. These are moist areas with continual disturbance and support large weedy populations. Such disturbances probably have no evolutionary precedent, and also create absolutely ideal conditions for invasions by exotics. Sewage treatment ponds provide bare substrate and nutrient enrichment, and–not coincidentally–support some of the most vigorous thistle stands in the park.

Grazing of trespass cattle and horses is a problem in Mesa Verde, punctuated by numerous fence breaks on the park's southern boundary. Grazing compacts the soil and reduces native grasses, and the animals may disperse exotic seeds. One example illustrates the extent to which grazing affects native flora. In Navajo Canyon, the average cheatgrass cover was 40 percent between 1980 and 1989. Fences were erected in 1987, and native grasses were returning to the area by 1990. In 1991, western wheatgrass, slender wheatgrass, and salina wild rye covered >60 percent, and cheatgrass was reduced to <20 percent. It has taken only 4 to 5 years to return the area to a nearly natural native flora.

> Of all the many functions our national parks perform, one of the most important is maintaining examples of natural ecosystems populated by native biota. Today these systems are continually shrinking in size and ecological integrity. In many areas the public has become so accustomed to seeing landscapes dominated by exotic species that they think these are the normal condition (Heywood 1989). Aldo Leopold, in his classic essay on the land ethic, wrote that the ecological damage that already has occurred in the southwest "is quite invisible to the tourist who finds this wrecked landscape colorful and charming (as indeed it is, but it bears scant resemblance to what it was in 1848)."
>
> To the credit of past and present managers, the vegetation of MVNP is still largely intact. To keep it that way, in the face of impending global-scale changes in climate and human impact, will require insightful research, enlightened and assertive management, and informed public support.

Biological Invasions

More than a dozen exotic species are considered troublesome at MVNP, but to illustrate the extent of such invasions and possible management scenarios, we will discuss the two thistle species further. Two of the most conspicuous invaders, Musk thistle and Canada thistle, have life history characteristics that make them potentially serious threats to the integrity of the park's natural vegetation. They display rapid rates of population growth, relatively short life cycles, early reproductive maturity, high reproductive allocation, pollination by wind or by generalist pollinators, and rapid response to resource availability. All these are general characteristics of colonizing plant species that can successfully enter new habitats following disturbance (Bazzaz 1986).

In 1976, economically threatening populations of Musk thistle species were located in eastern Colorado (Dunn 1976). Since then, Musk thistle has spread at an alarming rate. Musk thistle is a biennial, reproducing from seed exclusively. Canada thistle is more difficult to control because of horizontal adventitious roots that may extend 2 m deep (Hodgson 1968; Rees 1990).

Control of Biological Invasions

Control of Musk and Canada thistles should be geared specifically to the extent of the invasion and the degree of expected recurrence of disturbances. In MVNP, only the most extensive disturbances–large, hot fires, waste treatment, waterline construction–facilitate invasion of large acreages of thistles. Thus, treatment of weedy patches of various size and severity must be weighed carefully. Methods used to curtail thistle invasion include:

A. Biological control strategies for Musk thistle: *Rhinocyllus conicus* (Frowl) and *Trichosirocalus horridus* (Panzer) are thistle weevils, which have been used extensively in the U.S. for control of Musk thistle (McCarty and Lamp 1982; Rees 1982). *R. conicus* has spread into MVNP from surrounding agricultural land. In the spring, *R. conicus* females oviposit on the developing flower bud bracts, moving from primary to lateral buds as they become oversaturated with eggs. Eggs hatch in 6 to 8 days, and larvae burrow into the receptacle, reducing seed viability. *T. horrendus* attacks the stems and crown and produces feeding scars that allow entry of pathogens, further weakening the plant. Together they are effective in controlling Musk thistle.

Another insect species, *Vanessa cardiu* L. is presently established on thistles in many areas. *V. cardui*, the painted lady butterfly, is a migratory herbivore than cannot tolerate winter temperature, migrating to the southwestern U.S. and Mexico in fall. The larvae are locally effective herbivores of Canada and Musk thistle (Larry Hays, Natural Resource Specialist, Wind Cave NP, pers. comm.).

In the summer of 1992, systematic releases of *T. horridus* were made in Morefield Canyon, a densely thistle-infested area of MVNP. One hundred individuals were released on specifically tagged experimental plants in May, 1,000 in June, and control plants were paired with experimental plants. Native thistle species were monitored along with Musk thistles for possible infestations. First year result summaries show 1,748 seedhead weevils emerged from 106 Musk thistle seedheads and only one seedhead weevil emerged from 30 native thistle seedheads. We are confident that the success of the biological control agents by intentional and accidental introductions from surrounding lands will be effective in reducing the spread of Musk thistle in MVNP.

B. Use of mechanical control: Removal of Musk thistle biomass prior to "bolting" (establishment of seed head) seems a reasonable approach to eradication. In MVNP, to the extent possible with YCC, the hazardous fuel crew, the road crews, trail crews, ruins stabilization crew, and concessions personnel, inflorescences have been removed from bolt-

Continued on page 18

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ing plants prior to seed shed (in 1985-1992). Musk thistles are cut just below ground level in early summer. Generally a well developed rosette has enough root mass to produce a second and often a third head. Elimination of the current year's growth depletes the root carbohydrate reserves and plants experience increased mortality and reduced fecundity.

C. Use of Chemical control: Herbicides are effective means of eradicating most species of thistle. Applications of picloram, Round-up, Glean, Curtail, and other commercial preparations are used locally. Mesa Verde's policy has been to avoid introduction of herbicide into the ecosystem whenever possible. However, because of the extent of the problem, a combination of limited chemical treatment, in conjunction with mechanical and biological controls, is under consideration (B. Heyder, pers. comm.).

Looking to the Future

Biological invasion on disturbed habitats within MVNP illustrates the complexity of problems created by species migration and the role of human interference in plant establishment. Although weedy species are adapted to exactly the habitats that humans maintain, their positive influences -- soil stability and erosion prevention for example – may be overridden if they tend to re-direct the native successional process. The extent of ecosystem disturbance and the proximity to seed sources of aggressive weeds have created at MVNP a critical biological invasion.

Although we cannot yet predict with confidence the long-term effects of exotic plant invaders in MVNP, from other studies we know that changes in community or ecosystem function following establishment of exotic species has not always been significant; the potential effects of the new species range from modest usurpation of resources from many native species (hence no extinctions) to intense competition with one or a few natives species, with significant competitive displacement of the native(s) (Westman 1990).

Invaders may have positive ecosystem effects, especially with regard to repair of damaged ecosystems. For example, weedy herbaceous invaders may sequester nutrients more efficiently than the native species in severely disturbed sites (Mooney and Drake 1989). Despite substantial research to date, we still can make only very general predictions about which species are likely to be successful invaders or which communities are most susceptible to invasion. Each species and situation must be examined individually. (Bazzaz 1986; Westman 1990).

Sites disturbed before 1970 and abandoned to natural successional sequences support native flora in Mesa Verde today. But given the rapid expansion of exotic thistles in the park and surrounding region in the last few decades it appears likely they will spread to an even greater area in the near future, especially if disturbances continue to occur.

Disturbance of native vegetation, either natural or anthropogenic, is nearly always inducive to establishment of exotic species in new habitats (Westman 1990). Invasion was particularly severe in the record high precipitation of May 1992. In some areas of MVNP where spring moisture remains high and disturbance is continual (e.g. sewer ponds and surroundings), thistles predominate despite dense grass cover. What actually happens on any particular site depends on variables such as intensity of disturbance, weather conditions in the first years after a fire, and the local seed bank of aggressive exotic weeds.

Floyd-Hanna is a professor at Prescott College, Prescott, AZ; Romme is a professor of ecology at Fort Lewis College, Durango, CO; Kendall is a professor and entomologist at Fort Lewis College; Loy is a GIS Specialist at MVNP, and Colyer is Natural Resource/Park Ranger at MVNP.

Chenopodium fremontii, lambs quarter or goosefoot, growing in the 1989 Long Mesa burn one year after the fire. Photograph taken October 1990 in Mesa Verde NP.

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Wild Turkey Restoration at Indiana Dunes

By Eddie Childers

Young male ("jakes") wild turkeys (left) strutting and preparing for the spring breeding season. (*Photo by Randy Childers*)

Wild Turkey Hen (right) is intrigued by the camera. (*Photo by Eddie Childers*)

The eastern wild turkey originally inhabited much of the presettlement land east of the Mississippi River and was a valued resource for settlers and native Americans. Northwestern Indiana supported wild turkey populations throughout the 1800s; however, wild turkeys were extirpated thereafter, following loss of habitat due to intensive logging operations and exploitation by settlers, native Americans, trappers and hunters.

By the early 1940s wild turkeys did not exist in Indiana (USFWS 1987); however, since then, Indiana has restored the wild turkey to much of its original range where suitable habitat exists.

Wild turkey restoration is a successful management technique that involves live trapping the birds and transporting them to suitable habitat areas where no turkeys are. Midwestern states that have reported success with such programs include Missouri, Wisconsin, Michigan, Ohio and Illinois. In fact, wild turkeys now are known to occupy oak-savanna type habitats in Illinois, similar to the oak-savanna habitat found at Indiana Dunes National Lakeshore (Sullivan and Robinson, 1993). Suitable habitat appears to be one of the key limiting factors to successful wild turkey restoration.

Indiana's restoration efforts began in the mid 1950s and have accelerated rapidly during the 1980s, with an estimated 1,923 released birds at 127 sites throughout Indiana (Backs and Eisfelder, 1990). Wild turkeys now are present in more than 60 counties in Indiana and their numbers and range continue to grow (Ind. Div. of Fish and Wildlife, 1993). Successful statewide reintroduction of the wild turkey by the Indiana Department of Natural Resources (IDNR) suggested that restoration could begin at Indiana Dunes NL. GIS analysis was used to evaluate the habitat suitability for wild turkey restoration in the East Unit of Indiana Dunes NL based on IDNR's guidelines.

Wild turkey population growth and dispersal in newly restored areas is influenced by land use, human population levels, and physiography, among other factors. Selection of suitable release areas became an important topic of investigation for IDNR wildlife biologists as public pressure to consider marginal quality turkey habitats increased throughout Indiana (Backs and Eisfelder, 1990). Consequently, criteria and guidelines for wild turkey release priorities in Indiana were developed by IDNR to help agency personnel and the public better understand how restoration priorities are determined in Indiana. IDNR's guidelines for wild turkey restoration criteria are given for three levels: Level 1 (optimum), Level 2 (less than optimum), and Level 3 (poorest), based on the estimated potential for wild turkey establishment and growth at a proposed release site (Backs and Eisfelder, 1990).

The GIS analysis used the 68 previously classified plant communities for the East Unit of the National Lakeshore and reclassified them into the IDNR Level 1 habitat category types, that included forested (hard/soft mast-producing species; scrub/brush seral stages; openland (meadows, pastures, fields); human development (paved areas); and other habitat types (e.g. open water). The total area for each of the habitat types was generated for the East Unit of Indiana Dunes NL and compared with the IDNR guidelines to evaluate habitat suitability, using *r.reclass* and *r.report* (GRASS 4.0, 1991).

The wild turkey habitat in the East Unit meets most of the area requirements mandated by the IDNR. Forest cover, including hard and soft mast-producing species, shrub and brush seral stages, openland, and human development are all within 5 percent of the recommended ranges of Level 1 (optimum) habitat recommended for wild turkey restoration.

The East Unit does not meet the human development criteria, defined as <12 people and <0.8 km rural roads/km2. Human populations also are much higher than IDNR guidelines specify, due to the Dune Acres and Beverly Shores communities located within the boundaries of the National Lakeshore; however, barriers to wild turkey population expansion within the East Unit are minimal or nonexistent if these criteria are not considered.

The East Unit does meet other primary Level 1 criteria established by the IDNR, including requirements that the proposed release areas are between 25 and 50 km2 in size and are currently unoccupied by wild turkeys. Total area of the East Unit is approximately 43 km2 and no wild turkeys exist there today.

Reintroducing wild turkeys to the East Unit of the National Lakeshore would provide the added benefit of protection of a small, newly established population from hunting and poaching. Hunting is not permitted at Indiana Dunes. Furthermore, the population could increase in size within the National Lakeshore from an initial stocking, expanding and migrating to areas outside park boundaries, thereby providing hunting opportunities to residents on private lands in northwestern Indiana were none exist today.

The influence of wild turkeys on plant and animal communities within the National Lakeshore will be assessed before an active wild turkey restoration project is implemented. While impacts on plant and animal communities may be minimal, the effects wild turkeys have on endangered plant species and other communities are presently unknown.

Childers is with the National Park Service, Indiana Dunes NL.

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Regional Highlights

Pacific Northwest Region

A 1992 survey of spotted owls in Crater Lake NP recorded a total of 29 owls in the park–an unexpectedly high number that included owls at an unexpectedly high elevation.

Most spotted owls occur west of the Cascade divide, but four of the pairs found at Crater Lake were on the east side of the park. Also, although most spotted owls occur in fairly low elevation old-growth coniferous forests, sightings at Crater Lake included one at 6,550 feet–the highest at which a spotted owl nest ever has been found.

The survey involved a cooperative team effort among the Oregon Department of Fish and Wildlife, the U.S. Forest Service, and NPS.

Western Region

A recent publication by Dr. Lisa Graumlich (Professor at the Laboratory of Tree-Ring Research and Director of the Institute for the Study of Planet Earth at U/AZ), "A 1000-Year Record of Temperature and Precipitation in the Sierra Nevada"–Quaternary Research, 1993;39:249-255), has attracted considerable attention with its documentation of extensive drought periods during previous centuries. Summaries of her findings and their possible implications for both park ecosystems and State water supplies were covered by local newspapers as well as by the *New York Times*. Dr. Graumlich is a principal investigator on the Sierra Nevada global change research program.

* * *

Research Scientist David Parsons has been asked to serve on an ad hoc committee on ecosystem management by the Ecological Society of America (ESA). NPS representation in such activities is critical in building the credibility of NPS science activities, Parsons notes, as well as in assuring the committee's findings are applicable to park issues. Parsons also has been asked to serve on an independent science team appointed to assess the current status and management alternatives for old growth and associated ecosystems of the Sierra Nevada...a study mandated by Congress.

Parsons continues to serve on the board of editors for the ESA journal, *Ecological Applications*. The journal is interested in publishing more articles related to national park resource issues, and Dr. Parsons encourages potential contributors to contact him at Kings Canyon NP/Sequoia NP, Three Rivers, CA 93271-9700.

North-Atlantic Region

John T. Tanacredi and Robert P. Cook of Gateway NRA at Floyd Bennett Field in Brooklyn, N.Y., are co-authors of two recent papers: "Interagency Cooperation in Restoring Freshwater Wetlands in an Urban National Recreation Area," published by the National Institute for Urban Wildlife (*Wildlife Conservation in Metropolitan Environments*, 1991, *NIUW Symp. Ser. 2*), and "Management Strategies for Increasing Habitat and Species Diversity in an Urban National Park," (*Ecosystem Management: Rare Species and Significant Habitats*, NY State Museum Bulletin 471. 1990. pp 248-250.)

Tanacredi is either the sole or a participating author in the following six publications: "The effects of low doses of waste crankcase oil on *Melita nitida* Smith (Crustacea: Amphipoda)," in *J. Exp. Mar. Biol. Ecol.* 166 (1993) 39-46; "Naphthalenes associated with treated wastewater effluents in an urban national wildlife refuge," *Bull. Environ. Contam. Toxicol.* (1990) 44:246-253; "Is Commercial shellfish harvesting compatible within an urban national wildlife refuge?" *Fresenius Envir. Bull.* (1993) 2:174-178; "Secondary production of the amphipod *Ampelisca abdita* Mills and its importance in the diet of juvenile winter flounder in Jamaica Bay, NY, *Estuaries*, (June 1992) 15:2, pp 193-203; "Coastal zone management practices at an urban national park," *Envir. Mgmt.* Vol. 7, No. 2, pp 143-150; and "Natural resource management policy constraints and trade-offs in an urban national recreation area," from *Proceedings Natl. Symp. on Urban Wildl. Conf.* on Integrating Man and Nature in the Metropolitan Environment, 1986.

National Capitol Region

The ecological rejuvenation of Kenilworth Marsh continues to progress at a pace that has far exceeded expectations. The growth of planted and volunteer marsh species has reached the point where one would believe this fresh water tidal marsh had long been in existence and had not just this year been established upon dredge material. A monitoring committee comprised of many agencies including NPS, USFWS, EPA, Corps of Engineers, District of Columbia, Interstate Commission on the Potomac River Basin, and Metropolitan Washington Council of Governments has been documenting the restoration process.

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Results of the Dutch elm disease symposium, co-sponsored by the NPS and Michigan State University, have been published in M.B. Sticklen and J.L. Sherald (eds), *Dutch Elm Disease Research: Cellular and Molecular Approaches*. Springer-Verlag, New York. 1993.

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James Patterson, Research Agronomist at the NPS Center for Urban Ecology, has developed a micromorphologic technique coupled with image analysis to study human impact on soil systems.

* * *

Jonathan Hoeldtke participated in the service-wide gathering of the White-tailed Deer Committee to discuss progress with the draft management alternatives. John Hadidian participated in the Social Progress Workshop at Easton, MC as part of the Human Dominated System's Directorate Core Project; Phase II of the Project has been funded. Hadidian, Bill Hebb, and John Howard attended the R-MAP Workshop in Boston, and Hadidian is chairing the section for research for the 3rd International Wildlife Symposium to be held in Seattle, WA in the fall of 1994.

Southeast Region

Dr. Suzette Kimball, former Research Ecologist at the NPS/CPSU, University of Virginia, is the new Deputy Assoc. Regional Director for Natural Resources and Science in the Southeast Region. Dr. Kimball earned her BA and BS degrees from the College of William and May, her MS from Ball State in geology and geophysics, and her PhD from U/VA in environmental sciences and coastal processes.

While at the CPSU, Dr. Kimball served as the Barrier Island Global Climate Change Coordinator for the SE, SW, North Atlantic, and Mid-Atlantic Regions. Prior to joining NPS in 1991, Dr. Kimball was Co-director of the Center for Coastal Management and Policy and an Assoc. Prof. at the Virginia Institute of Marine Science, as Chief of Coastal Morphology Unit of the U.S. Army Corps of Engineers, and as a Research Physical Scientist at the Corps' Waterways Experiment Station in Vicksburg, MS. She is a certified Professional Geologist, who has served on a variety of boards and committees, including chairperson for the VA State Board of Geology, vice-president of the Mid-Atlantic Shore and Beach Preservation Society, and chairperson of the Nearshore Research

Group of the American Geophysical Union. She began her new duties at the Southeast Regional Office on July 19.

* * *

The NPS Coastal Parks CPSU, previously located at U/VA, has been relocated to NC State University. Dr. Ted Simons can be reached there at: NPS/CPSU, Campus Box 7106, Raleigh, NC 27695-7106. FAX (919)515-3439. The NPS has a long history of collaboration with NC State faculty and staff and will continue with coastal parks projects such as the groundwater studies at Cape Hatteras, GIS support, development of I&M protocols, and migratory bird research.

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Recently published reports include:

- Nodvin, S.C., J. Rigel, and S.M. Twigg. 1993. *An Indexed Reference Database of the Great Smoky Mountains, NC and TN*. NPS/SERGRSM/NRTR 93-08.
- Nix, L.E. and J. Barry. 1992. *Investigation of the Impacts of Clearcutting, Feral Hogs, and White-tailed Deer on the Native Vegetative Resources of the Congaree Swamp National Monument*. NPS/SERCOSW/NRTR 93-09.
- White, P.S. and R. Busing. *LTERM: Long-term Monitoring and Research in Great Smoky Mountains NP: Vegetation Monitoring and an Assessment of Past Studies*. NPS/SERGRSM/NRTR 93-10
- Rogers, C., M. Ratnaswamy, and R.J. Warren. *Vegetation Communities of Chickamauga Battlefield NMP, GA*. NPS/SERCHCH/NRTR 93-11.
- Schmidt, T.W. *Community Characteristics of Dominant Forage Fishes and Decapods in the Whitewater Bay Estuary, Everglades NP*. NPS/SEREVER/NRTR 93-12.
- Van Cleave, R. and A.Van Cleave. *Trail Use in Cataloochee, Balsam Mountain, Elkmont, Smokemont and Tremont Areas of Great Smoky Mountains NP*. NPS/SERGRSM/NRTR 93-13.

Meetings of Interest

1993

Oct. 13-16 **SOCIETY OF VERTEBRATE PALEONTOLOGY,** 53rd Annual Meeting at Ramada Inn Classic Hotel, Albuquerque, NM, hosted by the NM Museum of Natural History and Science.

Oct. 17-21 **HUMAN ECOLOGY AND CLIMATE CHANGE: THE ROLE OF PARKS AND PROTECTED AREAS**, an invitational workshop at U/WA's Pack Forest, hosted by Daryll R. Johnson and David L. Peterson of the U/WA's NPS/CPSU. To address human interaction with climate change, for which NPS and other agencies have research responsibility. Key papers will be published in a special issue of *Society and Natural Resources*.

Oct. 25-28 **SECOND BIENNIAL CONFERENCE ON RESEARCH IN COLORADO PLATEAU NPs**, at Northern AZ University, Flagstaff; highlighting biological, cultural, social, and physical science research in NPs and related areas on the Plateau. Contact: Mark Sogge, CPSU/NAU, Box 5614, Northern Arizona U, Flagstaff, AZ 86001; (602) 523-9090.

Nov. 5-6 **PROTECTING INTEGRITY AND ETHICS**, at Holiday Inn, Bethesda, MD; sponsored by Public Employees for Environmental Responsibility (PEER); speakers will include James Baca, Director of BLM; Dan Beard, BLM Commissioner; Jim Lyons, Asst. Secty. for Natural Resources and Environment at Agriculture, and Congresswoman Patricia Schroeder, among others. Contact PEER, 810 First St., N.E., Suite 680, Washington DC; (202) 408-0041.

Nov. 11-13 **NATIONAL WATCHABLE WILDLIFE CONFERENCE**, Corpus Christi, TX. To explore ways to become more effective at conservation, education, and economic development through watchable wildlife efforts. Contact Gary Graham, conf. co-chair (512)448-4311, or Mary Garrett, conf. coordinator (512) 888-5400.

Feb. 23-25 **2nd SYMPOSIUM ON SOCIAL ASPECTS AND RECREATION RESEARCH**, at San Diego, CA; hosted by USFS Pacific SW Research Station, BLM, and the Social Aspects of Resource Management Institute at CA State Polytech U, Pomona. Contact Lisa Maggiore, (909) 869-4591.

Mar. 23-25 **5 YEARS AFTER THE EXXON VALDEZ OIL SPILL**, An International Conference on Prevention, Response, and Oversight; sponsored by the Alaska Sea Grant College Program, U/AK, Fairbanks. Contact Brenda Baxter, U/AK, Fairbanks, 99775-5040; (907) 474-7086.

May 4-6 **1994 GEOLOGIC SOCIETY OF AMERICA, ROCKY MOUNTAIN SECTION MEETING,** Durango, CO; Papers from a platform session on NPS Paleontological Research, chaired by Vincent L. Santucci, will be published in a symposium volume. Contact Santucci at Petrified Forest NP, PO Box 2266, Petrified Forest, AZ 86028; (602) 524-6228 x227.

1994

June 7-10 **FIFTH INTERNATIONAL SYMPOSIUM ON SOCIETY AND RESOURCE MANAGEMENT**, CO/State/U, Fort Collins, CO. Michael J. Manfredo, program chair, has called for papers by Nov. 1, 1993, to Manfredo, Human Dimensions in Natural Resources Unit, CO/State/U, Fort Collins, CO 80523.

Aug. 28-Sept. 2 **6th ANNUAL INTERAGENCY WILDERNESS CONFERENCE,** tentatively scheduled for Santa Fe or Albuquerque,NM.

20th Annual Natural Areas Conference

"Conservation in Working Landscapes" was the theme of the 20th Annual Natural Areas Conference, convened by the Natural Areas Assn. in cooperation with the Maine State Planning office and held June 22-26 at U/ME in Orono. More than 500 attendees (the most thus far) came from as far away as Poland and Brazil. Topics ranging from natural areas aesthetics to sampling design were covered in about 143 papers. The 66 conference sponsors included Georgia Pacific and L.L.Bean, and underwriters were BLM, NPS, NOAA, EPA, USFWS, USFS, and the Canadian Wildlife Service.

More than 40 posters and 21 symposia covered inventory and monitoring, biological diversity, marine ecosystems, wildlife conservation, communications and landowner contact, fire management, botanical conservation, rare and endangered species, land aesthetics, old-growth, and global perspectives. Fifteen field workshops, pre- and post-conference field trips, and round-table lunch discussions allowed extended access to speakers. An address by Dr. George Woodwell, Director of Woods Hole Research Center, was followed by a question and answer session on the status of the National Biological Survey. Eight NPS people gave papers, talks, or acted as moderators, and Acadia NP staff hosted 2 of the field workshops.

The 21st Annual Conference is scheduled for southern Florida.

Craig Shafer
NPS Ecologist, WASO

Seasonal and Diurnal Discharge Fluctuations In Medano Creek, Great Sand Dunes National Monument

By James P. McCalpin

Medano Creek at the Great Sand Dunes National Monument has long been noted for its unique surge-flow behavior (Bean, 1977); Schumm and others, 1982). However, little was known of the discharge characteristics of the creek because it never had been gauged. The impetus for this collection of multi-year baseline discharge data was the projected decline of the regional water table (as much as 150 ft) underneath Medano Creek, due to groundwater pumping on adjacent property north of the Monument. The projected decline was thought to pose potential adverse effects to the surge flow in Medano Creek, and possibly to the NPS water right.

The 2-year study began in June 1991. Two standard dimension 3 ft-wide Parshall flumes were constructed of plywood and sheet metal and installed in Medano Creek at two locations. Because the area is in Wilderness, flume components were hand-carried to the sites and assembled on site, without the aid of machinery. The Boundary flume is located 5 km downstream. These flumes record creek stage via a float gauge and Omnidata (TM) DP-115 data logger in an adjacent stilling well. The Boundary flume was installed on June 28, 1991 and has a continuous record of discharge measured hourly. Corresponding measurements of depth to shallow groundwater in the floodplain are given in McCalpin (1992).

Discharge of Medano Creek at the Boundary flume is shown in Figure 1a for the 16-month period July 1991 to November 1992. The record begins after the 1991 peak snowmelt had occurred, and discharge had decline to less than 10 cfs (cubic feet per second). The mid- and late-summer seasons in both 1991 and 1992 are marked by a slow decline in discharge (due to decreasing baseflow from snowmelt), interrupted by two types of increases in discharge.

The largest discharge increases come from summer rainstorms. Large storm systems, such as the one in August 1991 (Fig. 1) can increase discharge up to 15 cfs, with the receding part of the hydrograph lasting up to one month. Smaller storms (such as mid-August 1992) create smaller flow increases (7 cfs) lasting a shorter time (one week). On more detailed hourly graphs of discharge (McCalpin, 1992) even smaller rainstorm effects can be observed–increases of 2-3 cfs over several hours.

The second summer increase occurs on July 16 of each year, when about 5 cfs of water is returned to Medano Creek from an irrigation diversion at Medano Pass. This increase merely shifts the declining part of the hydrograph up by about 5 cfs, and does not alter the overall trend.

In both 1991 and 1992, surface flow declined to a winter baseflow of ca. 3 cfs by October 1. Flume measurements from mid-October through late March were made only by visual observations every 2-6 weeks because stilling wells were frozen.

Spring snowmelt began rapidly in early April 1992, and reached discharges of over 30 cfs (peak=44 cfs) that lasted for two months. The pronounced peaks and troughs in the snowmelt discharge record reflect variations in weather, mainly in temperature, as recorded by the weather station at Monument Headquarters. The highest discharge peaks occur during warm, sunny

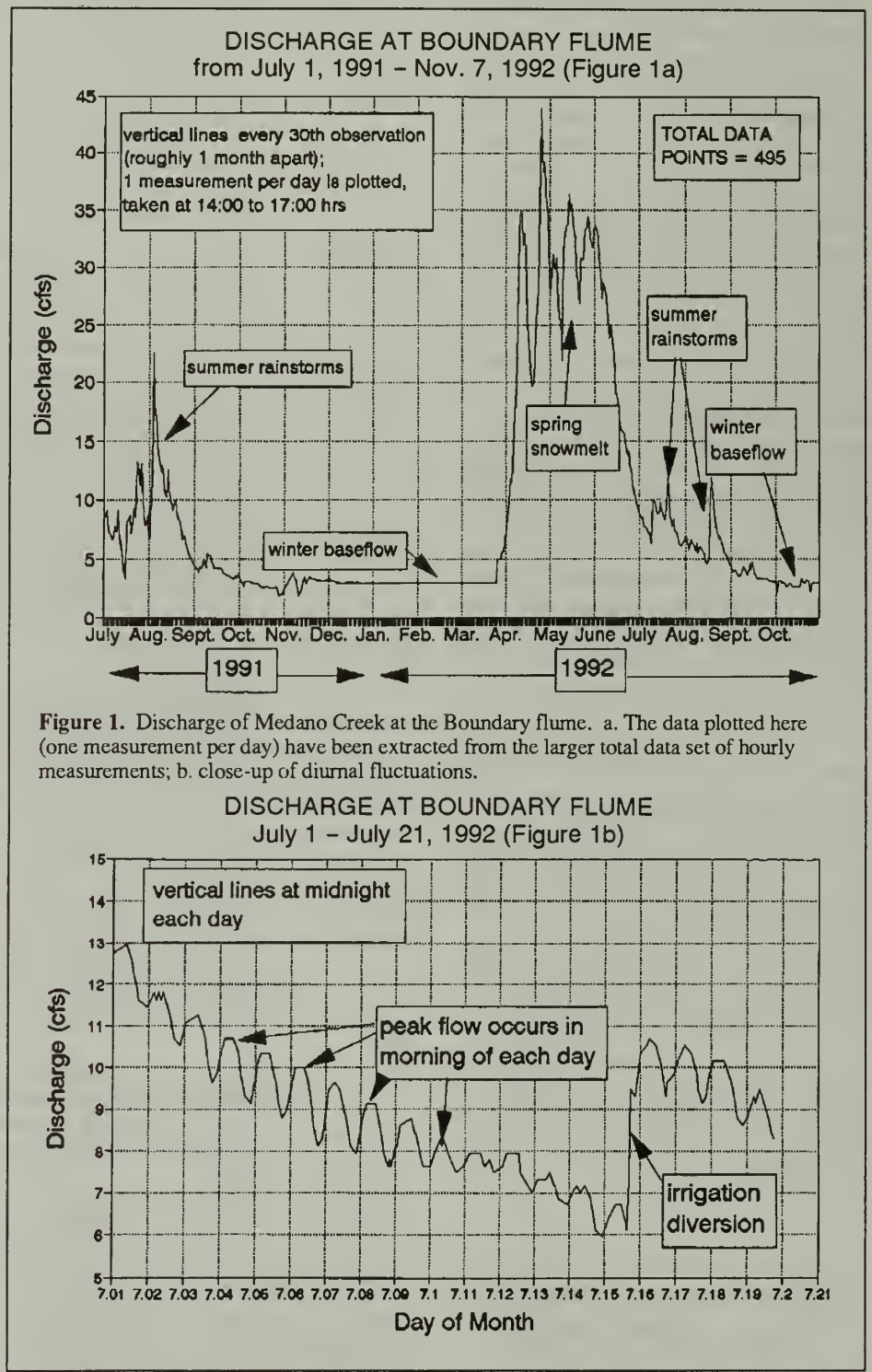

Figure 1. Discharge of Medano Creek at the Boundary flume. a. The data plotted here (one measurement per day) have been extracted from the larger total data set of hourly measurements; b. close-up of diurnal fluctuations.

Supt. William E. Wellman examines the Boundary flume at Medano Creek.

weather when snowpack is melting rapidly. Troughs in discharge are created by cool, cloudy weather systems accompanied by light snow. For example, cooling of 10 dgrees F. during mid-April and early May led to decreases of 15 and 20 cfs in discharge, respectively, merely by suppression of solar-induced snowpack melt. Once the surface snowpack was melted from all but the highest parts of the drainage basin, discharge declined rapidly, dropping from ca. 35 cfs in early June to <10 cfs in early July. In a typical year this decline would continue in an exponential curve unless interrupted by summer rainstorms or irrigation diversions.

Unexpectedly, we observed significant diurnal fluctuations in discharge throughout the year in Medano Crek (Fig. 1b). During the initial 1992 spring snowmelt (April 1-9), the peaks and troughs of discharge appeared 2-3 hours later at the downstream (Castle Creek) flume than at the Boundary flume. Peak flow at the Boundary flume occurred at about 8-9 p.m., after the hottest part of the day, but did not appear at the Castle Creek flume until midnight. The timing of peak discharge in the early evening, and the lag time between the flumes, suggests that each day a "slug" of snowmelt water enters the channel from high in the basin during the late morning and afternoon, and this slug travels downstream at about the velocity of water in the stream. To travel the ca. 5 km between the flume sites in 3-4 hours, velocities of 2-3 ft/sec are indicated. Current meter measurements confirm this as the average water velocity in the channel.

In contrast, the fluctuations during June-September are exactly in phase between the two flumes (Fig. 1b). This similarity is unusual, and suggests that a simultaneous mechanism is controlling flow at both sites. This mechanism may be phreatophyte transpiration by streambank cottonwoods, which would withdraw water from Medano Creek. As discharge decreases throughout the summer and fall, so does the amplitude of diurnal fluctuations. For example, during the spring snowmelt (April 9-14, 1992) discharge fluctuates as much as 5 cfs at discharges of 15-30 cfs. By July, fluctuations are down to 1-2 cfs at discharges of 8-15 cfs. In early September fluctuations are less than 1 cfs at 4-7 cfs, and decrease to about 0.25 cfs in October at 3 cfs.

The seasonal fluctuations in discharge observed in Medano Creek are typical of mountain streams that receive most of their precipitation as snowmelt. In contrast, the diurnal fluctuations in discharge are unusual and have not previously been described in the literature in much detail. The diurnal fluctuations in Medano Creek thus have two unique aspects. First, the creek is one of the few well-documented cases of diurnal stream fluctuations supported by nearly 2 years of high-quality, hourly discharge measurements. Second, the diurnal fluctuations induce diurnal changes in the position of the surface flow terminus at Medano Creek. The terminus advances each day during the hours of peak discharge, and retreats upstream during times of low discharge. Observant visitors, who must wade across the creek to access the main dune mass, can now appreciate two rare fluvial phenomena at the same time--surge flow, and abnormally large diurnal discharge fluctuations.

Dr. McCalpin is president of Geo-Haz Consulting, Inc., of Estes Park, CO.

Letters

To the Editor:

Now that I am about to be Shanghaied to NBS (*Morituri te salutamus!*) I have one last act to do vis-a-vis *Park Science*, aside from wishing you well.

It is this. I note that with increasing frequency you are mentioning particular species of birds in *Park Science*. That is terrific, and clearly demonstrates a maturing publication.

However, there is one thing that you (and others: you are not alone) are doing, and which is incorrect. It is this: English-language vernacular names of birds around the world are carefully chosen, formal and precise names. They are also for that reason proper nouns. Thus, **English names of bird species are always capitalized.** There are no exceptions to this: it is uniform ornithological format. Pick up any ornithological journal or book in English and you will see what I mean. The format is for initial caps only; thus, Red-winged Blackbird, Greater Golden-Plover, Western Bluebird, but convention also leads to Common and Roseate terns–omitting the initial caps for the collective in strings of common names.

Aside from indicating exactly which particular species you are talking about, this practice cleanly obviates such ambiguities as "eastern bluebird": is this a bluebird in the decadent east, or *Sialia sialis*? Etc.

Off the soapbox. Best wishes for the continued health of *Park Science*.

Sincerely,

P. A. Buckley
NPS Senior Scientist

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Forest Ecosystem Management in the Pacific Northwest: A New Approach

By Edward E. Starkey
Research Biologist,
Cooperative Park Studies Unit, Oregon State University

On April 2, 1993, President Clinton held a Forest Conference in Portland, OR to address the existing forest management gridlock in the Pacific Northwest. For at least the last 20 years, management of federal forests in the region has been at the center of intense controversy. With the listing of the northern spotted owl as threatened under the Endangered Species Act, the debate moved to the courts. Currently, timber cutting on Forest Service and Bureau of Land Management lands within the range of the northern spotted owl has been essentially brought to a halt by federal court orders.

Following the Forest Conference, President Clinton created The Forest Ecosystem Management Assessment Team and two other working groups dealing with agency coordination and labor and community assistance. In his opening remarks, President Clinton stated the fundamental question for these working groups: "How can we achieve a balanced and comprehensive policy that recognizes the importance of the forests and timber to the economy and jobs in this region, and how can we preserve our precious old-growth forests, which are part of our national heritage and that, once destroyed, can never be replaced?".

The Forest Ecosystem Management Assessment Team was asked to identify management alternatives that attain the greatest economic and social contributions from the forests and also meet the requirements of the applicable laws and regulations, including the Endangered Species Act, the National Forest Management Act, the Federal Land Policy Management Act, and the National Environmental Policy Act.

From the beginning of this effort, agencies were explicitly instructed that they would be expected to work together in developing and implementing a regional forest plan. The Forest Ecosystem Management Assessment Team was further instructed to develop alternatives without regard to agency boundaries. Thus, all options were based on ecological conditions and objectives rather than agency jurisdiction.

Ten options were developed and analyzed, and subsequently included in a Draft Supplemental Environmental Impact Statement. These options included various combinations of Late-Successional Forest Reserves, Riparian Reserves, and prescriptions for management inside and outside of reserves.

Most timber cutting would occur outside the reserves. Size of the reserve systems varied from 4.2 to 11.5 million acres.

For all options, the team evaluated the likelihood of maintaining well-distributed habitat for populations of threatened marbled murrelets and northern spotted owls. Additionally, for seven of the options, similar assessments were completed for more than 1,000 plant and animal species that are closely associated with late-successional forests. The likelihood of maintaining connected, viable late-successional ecosystems was also evaluated. Likelihoods varied by option, but were generally related to the amount of late-successional forest included within reserve systems. Similar assessments were conducted for at-risk fish species and stocks, and these ratings were sensitive to degree of stream-side/watershed protection provided. Collectively these assessments probably represent the most extensive evaluation of biological risk ever undertaken to assist decision-makers in determining the degree to which an array of options might meet legal requirements.

Timber harvests under any of the options would be significantly less than levels of 1980-1989 (4.6 billion board feet per year), and ranged from 0.2 billion board feet per year to 1.8 billion board feet per year. A number of local communities would be seriously impacted by any of the options.

On July 1, President Clinton announced his selection of "Option 9" as the preferred alternative. This option includes approximately 7 million acres of congressionally reserved areas (eg., national parks and wilderness areas), 7 million acres of Late-Successional Reserves, 2.2 million acres of Riparian Reserves, 1.7 million acres of lands administratively withdrawn from timber harvest, and 4.9 million acres which would continue to be available for timber production and cutting. Approximately 1.2 billion board feet of timber could be cut each year under this option.

National parks represent approximately two million acres of the congressionally reserved areas included within Option 9. Although most national parks of the Pacific Northwest contain significant areas that are above tree line, these parks also contain invaluable stands of late-successional forests. For example, Olympic NP contains nearly all of the remaining uncut forest on the Olympic Peninsula, and is the cornerstone of any conservation strategy for the peninsula. Mt. Rainier, North Cascades, and Crater Lake NPs, along with adjacent U. S. Forest Service lands, also are integral components of Option 9. Redwoods NP contains the only significant federal forests on the north coast of California.

Implementation of Option 9 would significantly affect national parks and their management. Most importantly, the area of protected ecosystems in the vicinity of most parks would be greatly increased. Increased protection for Olympic NP is especially significant. The park and several small Wilderness Areas managed by the USFS contain approximately 960,000 acres. Under Option 9, an additional 500,000 acres of adjacent federal lands would be managed as a Late-Successional Reserve. Thus the effective size of the protected ecosystem would increase by more than 50 percent. However, because of past timber cutting, less than one-half of this additional area presently contains forests with late-successional characteristics. Therefore, it will be many decades before the Late-Successional Reserve becomes fully functional.

Significant additional protection is also provided for North Cascades and Mt. Rainier NPs, where nearly all adjacent federal lands would be managed as Late-Successional Reserves. Late-Successional Reserves would be established along portions of the eastern

Continued on page 25

Forest continued from page 24

and southwestern boundaries of Crater Lake, providing somewhat less protection than for the Washington parks.

Option 9 also provides increased opportunities for park managers to participate in regional land management planning. Regional coordinating groups may be established which would include park managers. Permanent technical support groups, with staff from all appropriate agencies, would carry out day-to-day activities, including coordination of monitoring, data information management, and sharing of information.

The team recommended that "federal agencies through the interagency coordination effort, should develop a multi-organizational resource monitoring system. Standards and guidelines that address design and quality control should be included." and "federal agencies in collaboration with public and private interests ..., should develop a research plan for the Pacific Northwest." As inventory and monitoring (I&M) programs are developed for national parks of the Pacific Northwest, park managers have an opportunity to contribute information which may be required to measure the effectiveness of the regional conservation strategy. Hopefully, this will be reflected in increased interagency cooperation and integration of I & M and research plans.

The scientific input to the process was essentially completed when President Clinton selected Option 9 as the preferred alternative. Now, policy-makers, the courts, and the public must decide whether the plan will be implemented. During the summer and fall, the plan will undergo judicial review to determine whether the current injunction on timber cutting can be removed or modified. Also, public and agency comments will be sought, as required by the National Environmental Policy Act.

Copies of both the ***Draft Supplemental EIS on Management of Habitat for Late-Successional and Old-Growth Forest Related Species Within the Range of the Northern Spotted-Owl*** and ***Forest Ecosystem Management: An Ecological, Economic and Social Assessment***, the Report of the Forest Ecosystem Management Assessment Team, are available from the Interagency SEIS Team, P.O. Box 3623, Portland, Oregon, 97208-3623 (503-326-7883).

The comment period on the SEIS ends Oct. 28, 1993, but allows plenty of review time. Each document is several hundred pages in length.

Dr. Starkey served as a member of the Forest Ecosystem Management Assessment Team, as well as the Recovery Team for the Northern Spotted Owl.

MAB Notes

Important issues addressed at the July 19-20 meeting of the U.S. MAB National Committee included the upcoming managers' workshop and funding of several research projects. The **U.S. Biosphere Reserve Action Plan Workshop** will be held Dec. 6-10, 1993 at Estes Park, CO. Of the 47 U.S. biosphere reserves (BRs), 44 expressed interest in participating in Plan development and planned to send representatives to the workshop. Beginning with a skeletal draft action plan, participants will produce a final draft action plan to guide biosphere reserve activities over the next decade or so. This will be the first national biosphere beserve managers' meeting since 1984, and will have broader representation, since the earlier meeting consisted largely of NPS biosphere reserve managers.

* * *

Research projects funded for FY 1993 included three that involved NPS biosphere reserves. The Human-Dominated Systems Directorate Core Project, Ecological Sustainability and Human Institutions, will characterize ecological sustainability, using case studies of the south Florida region, the Virginia Coastal Reserve, and the New Jersey Pinelands.

The Circumpolar Biosphere Reserve project will initiate several cooperative surveys and data exchanges and an exchange of managers between Archipelago Sea National Park in Finland and Glacier Bay NP and Preserve in Alaska. Both of these BRs face important challenges to commercial and Native subsistence fisheries management issues.

Biological, Socio-Economic and Managerial Concerns of Harvesting Edible Mushrooms on the Olympic Peninsula and in the Southern Appalachians will complement the core research of the Temperate Ecosystems Directorate, which will provide information to "...manage temperate landscapes for diversity, resilience, productivity, and sustainability for the long-term.

* * *

The **Mammoth Cave Area Biosphere Reserve**'s power to take regional action has been greatly strengthened by a cooperative agreement between Mammoth Cave NP and the Barren River Area Development District (BRADD). The Economic Development Administration has granted BRADD $50,000 for sustainable economic development studies in the BR area, and the Soil Conservation Service is administering a $5 million program in the area focusing on protection of groundwater integral to cave resources. The BRADD board of directors--the city and county officials directly affected--has voted to more than double the BR's present size of 80,000 acres.

* * *

Great potential for MAB regional and international cooperation has arisen with the establishment on June 10 of a biosphere reserve in northwest Sonora, Mexico. Three core areas totaling more than 1 million acres are included: the volcanic Pinacate region; Gran Desierto de Altar, a vast, mountain-studded area of sand dunes; and the Colorado River delta with some adjacent waters of the Gulf of California.

Secretary of the Interior Bruce Babbitt attended the dedication ceremony at Puerto Penasco, joining Mexico's President Salinas and Mr. Colosio, head of the Secretariat of Social Development, which will administer the reserve. Several Mexican government bodies are jointly developing a management plan. On the Arizona side of the border, Organ Pipe Cactus National Monument and the Cabeza Prieta National Wildlife Refuge provide large protected areas that could be part of an international regional MAB program. On-going community-based "town meetings," facilitated by the Sonoran Institute, are exploring ways to promote cooperation and implement biosphere reserve concepts in the region.

* * *

EuroMAB is making good progress with its **Biosphere Reserves Integrated Monitoring Program** (BRIM)). The purpose of BRIM is to "harmonize" the collection, reporting, and accessibility of scientific data from the 32-country, 175-unit EuroMAB biosphere network, which includes Canada and the U.S. Biological inventory data are the primary initial focus for developing the broad-based network.

Twenty-five inventory databases for birds have been completed and many more are expected. Biological records in some BRs span several centuries. A few BRs in the Czech Republic have floristic collections dating from the 16th to the 18th centuries. A computer program called MABBird has been designed to allow users to efficiently access, edit, and retrieve information contained in BR bird survey databases. Peace Corps volunteers may assist with computerization of inventory data in Eastern European biosphere reserves.

Napier Shelton
NPS Washington Office

Karst Groundwater Basins: An Abstract of Analysis

By Joe Meiman

The protection and conservation of aquatic resources poses special problems to resource managers; typically, drainage basins extend far beyond park boundaries. As any land use within the watershed is manifested in the water quality down-basin, the most effective resource management decisions are born from a watershed approach. A watershed strategy takes into account all land use activities occurring within a drainage basin and determines the effects of each activity on the water quality downstream. At Mammoth Cave NP, hydrologists have used a watershed strategy in analyzing karst* groundwater basins.

The analogy between a surface drainage system, with dendritic flow patterns converging on a master stream, and the transfer of groundwater through a cave system, is often used when describing flow through the karst aquifer of south-central Kentucky. Since in many fundamental ways a karst aquifer behaves as a surface stream network, similar sampling strategies, with important modifications, are used to document the water quality of a karst basin.

As the boundaries of a karst groundwater basin are being defined by qualitative dye tracing, non-conditional synoptic water quality sampling is conducted. Non-conditional synoptic sampling (extracting a sample on a fixed date regardless of flow condition) will provide the researcher with an inventory of contaminants in a cave stream or spring under the continuum of discharge conditions.

Furthermore, the investigator must measure, or at least best approximate, site discharge upon sampling. Discharge, when combined with parameter concentrations, yields mass flux (mass per time), which may provide valuable information regarding contaminant transfer from the surface to the subsurface. For example, mass flux data at Mammoth Cave NP reveal that flood pulse-producing sudden recharge events (rainfall) are the primary agents of groundwater quality degradation. When we have the highest water quantity we have the lowest water quality.

After flood pulses are identified as instruments of karst groundwater contamination, they must be parametrically quantified. Without frequent sampling, it is difficult to accurately measure the large fluctuations in many water quality parameters that occur in karst waters during and following storm events. As products of conduit flow aquifers, these fluctuations are commonly of high amplitude and short wavelength. However, even brief increases in certain contaminants may yield serious consequences at water supply springs, and have lasting detrimental effects on aquatic cave life. Therefore, storm event spring sampling must be included in any karst groundwater characterization effort.

It is vital that flood pulse sampling include a series of sequential samples beginning prior to the recharge event and continuing until flow and water quality approach antecedent conditions. Repeated, rigorous circum-storm water sampling at a particular spring or cave stream may reveal a unique combination of parametric response traits. A spring's storm response is actually composed of numerous overlapping subset responses, each originating from individual inputs or groups of inputs. The chemical and physical waveforms of a flood pulse are modified by various attributes unique to individual karst basins. Antecedent phreatic water within the conduit system may cause a significant delay between a spring's discharge response and the eventual arrival of storm-derived water. A flood wave may be compressionally propagated through a phreatic conduit possibly creating peak discharges well before the arrival of storm waters.

An analogy may lie as close as your backyard. A garden hose filled with water on a warm day immediately discharges warm water when the tap is turned on, and the arrival of the cool water, which actually caused the expulsion of warm water, may take some time. In the same way, it is possible that if the investigator only samples up to the peak discharge, a significant portion of the contaminant pulse will be missed.

Tracer dyes injected with the storm water runoff may help to identify the contribution of a particular subset of inputs to the whole storm response. In order to tag a flood pulse, the investigator must equip the spring with an automatic sampler. The sampling interval will be determined by factors such as the spring's relative response to recharge and groundwater flow velocities defined by previous quantitative tracing. At the onset of recharge, the fluorescent dye is injected into a sinkpoint with the runoff. Samples then will be analyzed for targeted parameters as well as the dye. An in-phase relation between the dye recovery curve and a contaminant pulse may not only identify the pollution source, but also suggest the amount of contaminant exported from that particular input.

A detailed account of flood pulse tagging and circum-storm sampling at Big Spring Groundwater Basin, Mammoth Cave NP has been written and is available to interested parties. An NPS Scientific Monograph also is being written by the author, describing holistic karst groundwater basin analysis. Write to: Joe Meiman, Mammoth Cave NP, Mammoth Cave, KY 42259

Meiman is Park Hydrologist at Mammoth Cave NP.

* Karst: A limestone region marked by sinks and interspersed with abrupt ridges, irregular protruberant rocks, caverns, and underground streams.

Hot Springs NP Considers Flood Control Alternatives

Hot Springs National Park and the adjacent city of Hot Springs, Arkansas, have been subjected to periodic devastating floods many times over the last century. In an effort to reduce the intensity and damage from floods, the City, the NPS, and the U.S. Army Corps of Engineers have been involved in a series of studies to determine alternative solutions.

The Corps has identified a preferred alternative: a 26 foot diameter tunnel through West Mountain (inside the park) to route flood waters away from the most vulnerable area of the park (the historic Bathhouse Row) and the city. Regional and WASO Water Resources Division staff have worked closely with the Corps on this project for many months and have succeeded in getting the Corps to name a distinguished panel of independent hydrogeologists to develop the strategy for feasibility investigations.

While the NPS is satisfied that maximum precautions will be taken to protect the springs and other resources of the park, the Service is reluctant to pursue this course. The Corps has applied for a Special Use Permit to drill a series of test wells to study the tunnel route. Rather than deny the permit request outright, NPS Director Kennedy has promised the Corps some positive alternatives that would be acceptable to the Park Service.

The NPS has named its own panel of experts to develop those alternatives to the tunnel proposal and a report was expected by the end of September.

Four New Videos Made in NPs Take Honors at Film Festival

Four national parks are featured in award winning videos, honored at the 30th National Outdoor-Travel Film Festival, sponsored this year by the Michigan Outdoor Writers Association. Brief reviews of the four were submitted to *Park Science* by K.R. Cranson, recently retired after a 31-year teaching career, most recently at Lansing Community College in Michigan.

***Yellowstone: Imprints of Geologic Time*, Blair Robbins, 1992, 27 min., Terra Productions, 2019 Fairview Ave. East, Suite K, Seattle, WA 98102, (206) 238-3080, $29.95**...Gives the gologic history of the world's first national park. Aimed at a popular audience, it affords a comprehensive review of Yellowstone's geologic record. All components are included, from the 2+ billion year old Precambrian rocks to the workings of geysers. A nice set of simple graphics illustrates the numerous geologic concepts presented. The presentation of wildlife early in the film is designed to capture attention of students in a classroom, but teachers interested in the geology message would do well to prepare students prior to viewing, preferably with some kind of handout or a worksheet focused on the geologic history of Yellowstone. As an introduction or review of the Yellowstone geology story it's the best I've seen in recent years.

***Isle Royal Reflections*, Frida Waara and Mike Settles, 1992, 22 min., On-Cue Production, 200 Timberlane, Marquette, MI 48955, (906) 249-1903, $24.95**... Impressions of this remote region by four artists, each using a different medium: photography, painting, writing, and sculpture. Abundance of water and variety of wildlife and vegetation are paramount in this look at the most isolated island national park in the United States. The film provides insight into how direct contact with natural areas can inspire creativity–a nice link between arts and the natural world.

***Grand Canyon: River of Dreams*, John Wilcox, 1992, American Adventure Productions, 3190 Baltic Ave., Aspen CO 81611, (303) 920-3777, $24.00**... received the Best Environmental Documentary award for exploring one of the earth's great river systems. The emphasis in definitely on adventure–the excitement of white water rides in the same boat with world champion river runners. Nice photography of the canyon walls and river illustrate the dramatic geology, but little dialogue contributes to this topic. Same is true for wildlife and vegetation along the canyon bottom. With proper introduction and study aids, this video provides a significant environmental story, told excitingly in an extremely scenic setting.

***Stephen Lyman: Warmed By the View*, Jonathan S. Felt, 1992, 12 min., Greenwich Workshop Gallery, 2600 Post Road, Southport, CT 06490, (800) 243-4260, contact producer for cost**... A nice, short introduction to interdisciplinary discussion in art, humanities, or social science topics, filmed at Yosemite National Park. There is far too little science content to be useful for science purposes, but the video certainly qualifies for the award it received–Most Unusual Treatment of an Outdoor Subject.

K.R. (Rod) Cranson
226 Iris Avenue
Lansing, MI 48917

T & E Workshop in Southwest Draws on Several Agencies

The Southwest Region's Division of Natural Resource Management and Science staff presented a threatened and endangered (T&E) workshop in Albuquerque, NM Aug. 18-20, 1993. The course featured substantial involvement from the New Mexico Natural Heritage Program, U.S. Forest Service, New Mexico Department of Game and Fish, New Mexico Energy, Minerals and Natural Resources Department, the Bureau of Land Management, a number of parks, and the Southwest Regional Office.

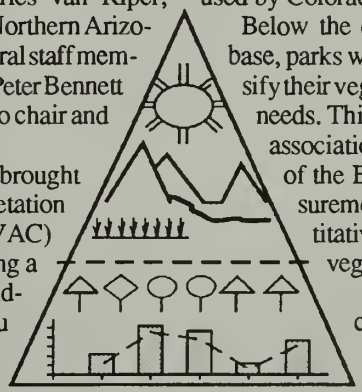
Highlights included a talk on the future of T&E species management by USFWS Regional Director Dr. John Rogers, as well as a field trip to the Rio Grande Zoo to learn about the captive breeding program for endangered species, including the Mexican wolf.

The program was co-funded by the Washington Office and organized by John Miller, Chief of the Resource Management Division at Padre Island National Seashore.

Colorado Plateau Vegetation Advisory Committee: A Working Model for Standardization

By Elena T. Deshler

The need to standardize a Colorado Plateau-wide vegetation classification scheme in relation to Geographic Information System (GIS) requirements was recognized two years ago, at the 1991 Colorado Plateau (COPL) Workshop. Charles van Riper, leader of the NPS CPSU at Northern Arizona State University, and several staff members identified the need, and Peter Bennett (CPSU/U/AZ) was named to chair and coordinate the effort.



Bennett has effectively brought the Colorado Plateau Vegetation Advisory Committee (CPVAC) vision into reality by creating a handbook that provides guidance to all Colorado Plateau parks. The handbook is based on the Brown, Lowe, and Pase vegetation classification system (BLP) and was presented on October 27-28, 1992, to 21 participants at a meeting to explain the methodologies and techniques suggested in the draft handbook.

At that meeting, Van Riper conceptualized the BLP hierarchical system in a triangle diagram (above). The top of the triangle represents the biogeographical realm; the base of the triangle represents the detailed quantitative measurements designed for intensive vegetation studies. The dotted line across the triangle stands for the mappable, standard vegetation classification level, based on climax plant dominants, that would be used by Colorado Plateau parks.

Below the dotted line level, along the base, parks will have the freedom to classify their vegetation to meet specific park needs. This level would incorporate the association and sub-association levels of the BLP, utilizing detailed measurements and assessments of quantitative, as opposed to qualitative, vegetation characteristics.

Dr. Charles Lowe, one of the co-authors of BLP, gave an historical perspective of the system, emphasizing the need to incorporate both field methodology and the BLP system in order to gain a COPL vegetation map. The COPS resource managers will be responsible for the continued use and additions to the handbook, thus providing a continually evolving process that will be molded to fit the needs of the users on the Colorado Plateau.

Deshler is a Biological Technician with the CPSU at Northern AZ Univ.

Shared Beringian Heritage Program Underway

By Dale Taylor

Editor's Note: This is the first of several articles planned to cover results stemming from the Shared Beringian Heritage Research Program.

Mysticism surrounds the narrow strait separating the continents of Asia and North America. This region, which today is ice covered much of the year giving rise to extremely cold water during the short summer, is near the heart of "Beringia." Beringia, the name used by botanist Hulten as early as 1937 (Matthews 1982), describes an area of Alaska and Siberia that was, in part, intermittently covered by seas (Fig. 1). Evidence points to the Bering Land Bridge between North America and Asia at numerous times beginning in the early Tertiary and as recently as 13,0000 and possibly 11,000 years ago (Hopkins 1967). This alternate formation and later covering of the land bridge by water as the continental ice sheets waxed and waned, provided opportunities for genetic and cultural exchanges and isolation.

The cultural and biological heritage of Beringia has been recognized for many years (Hopkins, et al, 1982 and Hopkins 1967). Prevailing political climate prevented proposals by Roberts (1981, 1984, and 1985) for an international research park in Beringia from reaching fruition. However, in 1986 the Beringian Heritage International Park project was established under the authority of the 1972 US-USSR Agreement on Cooperation in the Field of Environmental Protection, working group 02.04.20. Specific activities were developed by the working group in protocols of June and October 1987. The Agreement was reauthorized in May 1992 and included working group 02.04.40-44 dealing with establishment, management, policy, and research in the Beringian Heritage International Park.

In September 1989, American and Soviet planning teams recommended an international park in a report entitled the *Beringian Heritage Reconnaissance Study* (1989). Presidents Bush and Gorbachev issued a summit agreement in June 1990 calling for cooperation in studying ecology, archaeology, and cultural heritage in the Bering Strait. Though President Gorbachev stepped down from power following the September 1991 coup in the USSR, the process for establishing the park continued. Presidents Bush and Yeltsen issued a joint statement in June 1992 to reaffirm their vision of the Beringia International Park as formal recognition of the shared natural and cultural heritage of the Bering region. Legislation to establish the park is in various stages in both countries.

In response to these agreements, yet ever mindful of the political arena, where changes could influence final establishment of the park, the NPS embarked on a Shared Beringian Heritage research program. The international, multidisciplinary research program brings Russian and American scientists, resource managers, and Native people together in a long-term, integrated study of traditional lifeways, biogeography, and landscape history on the Seward and Chukotka Peninsulas (Schaaf 1992). Papers describing the research will be presented in future issues of *Park Science*. The purpose of this paper is to present preliminary results from botanical studies being conducted in Alaska and Chukotka as part of the Shared Beringian Heritage Program.

THE FLORA PROJECT

The Need

The intermittent emergence of the Bering Land Bridge favored an exchange between the two continents, predominantly the dispersal of plants from Asia to America. Knowledge of the flora, which will lead to understanding interchanges between two continents, although greater in Chukotka than in

Figure 1. The Russian Far East, Alaska, and portions of Canada outline the approximate area of "Beringia." *Drawing by Kate Solovjova.*

Alaska, is incomplete in both areas. Botanists from the Komarov Botanical Institute, St. Petersburg, Russia, have been collecting information in Chukotka for years.

On the other hand, Kelso (1993) describes the first plant collectors on the Seward Peninsula as naturalists on the early voyages of arctic exploration. They focused almost entirely on areas around the few harbors offering protection from the Bering Sea storms. Major inventories in the interior are few, but include the survey prior to establishment of the Bering Land Bridge National Preserve (Melchior) and work by Kelso (In prep.). The Bering Land Bridge National Preserve herbarium contains about 1,000 specimens and represents ongoing work. Little work had been done on non-vascular plants on the Seward Peninsula.

Project objectives are to: create databases for Bering Land Bridge National Preserve in a standard format that can be used by other parks; complete a checklist for different taxa; complete monographic descriptions of flora for comparison on a continental scale; complete geographic ranges; develop systems of biodiversity monitoring; create a standard geographical basis for the analysis of arctic biota; identify areas where intensive inventory and monitoring will be conducted on selected taxa; and develop general principles for database organization for analysis of floristic data.

Project Staff

An International Panarctic Biota Project is being organized by scientists from Russia and North America. The project is divided into categories of flora, mammals, birds, fish, invertebrates, etc. Project objectives fit with the overall objectives of the Beringian project and provide the added benefit of making the work a part of a circumpolar effort. An agreement was reached with leaders of the Panarctic Flora project in 1992 to begin in this "crossroads of the continents" with priority for work being done in Bering Land Bridge National Preserve.

Dr. Boris Yurtsev, Head, Laboratory of Vegetation of the Far North, Komarov Botanical Institute, St. Petersburg, (vascular plants), and Dr. David Murray, Curator of the Herbarium, U/AK Fairbanks (vascular plants), are leaders of the Circumpolar Flora project. Dr. Yurtsev has worked on the Chukotka Peninsula part of the Beringian International Park; Dr. Murray has worked in Alaska and headed the Herbarium for over 20 years. Co-Investigator Dr. Barbara Murray is Research Professor of Cryptogamic Botany and Honorary Curator of the Cryptogamic Collection at the U/AK Herbarium, and specializes in bryophytes and lichens. Dr. Sylvia Kelso, Colorado College (vascular plants), Dr. Mikhail Andreev (lichens), Dr. Olga Afonina (mosses), and Dr. Alexey Potemkin (hepatics), all of the Cryptogamic Botany Lab, St. Petersburg, and I completed the field crew. Dr. Alan Batten (database manager) and Carolyn Parker (herbarium assistant), Rich Harris, Anne Coupland, and Tauny Rogers (Bering Land Bridge National Preserve Resources Management staff) completed the working crews over the 2-year period.

After a 2-month field and laboratory season in 1992, the following preliminary results have been provided by specialists:

Vascular Plants (*David Murray*)

Collected were 669 plants, which translated into 2 or 3 times as many sheets of specimens. These were re-examined in the lab and now await data entry and labels, which the computer will print automatically, before breaking them into sets for distribution to Bering Land Bridge Preserve, Komarov Institute, and the Herbarium in Fairbanks.

Among the 480 taxa noted, one appears to be a new species and several are new to science at infraspecific ranks (subspecies or variety); 25 Asian taxa have been reported for the first time from North America; 30 taxa are new records for the Seward Peninsula as per the checklist of Kelso (manuscript), and more than 100 extensions of range on the Seward Peninsula are recorded. The final precise tally awaits further work and, most of all, a resolution of differing traditions in taxonomy and species concept manifest in the view of the Russians of the Komarovian school vs. the Americans.

Hepatics (*A. D. Potemkin*)

Generally it is true that the liverwort flora of arctic Alaska is poorly known, and prior to this study only about 20 species had been reported from the Seward Peninsula. Almost all the taxa collected represent additions to the flora of the Seward Peninsula. We found taxa new to arctic Alaska, new to Alaska, new to North America, and one taxon new to science.

During the expedition about 400 specimens were collected. These included about 150 taxa (126 species, 4 subspecies, 13 varieties, and 4 forms). Approximately 1/3 of all taxa (35 species, 2 subspecies, 8 varieties, and 3 forms) are new for arctic Alaska.

Some discoveries represent considerable range extensions. Three species were found in the Arctic, in the strict sense, for the first time; two species were known previously in North America only in the Northwest Territories, and one species only in Washington and British Columbia. Several taxa are new to North America. Before confirming the identification for some taxa among those apparently new to North America, it will be necessary to examine material at other herbaria.

A taxonomic description is being prepared for *Gymnocolea fascinifera*, a species new to science.

Mosses (*O.M. Afonina*)

Little has been recorded about the Seward Peninsula mosses, so many of the species found in 1992 represent new records for the

Continued on page 30

Russian scientists Dr. Olga Afonina, Dr. Alexey Potemkin, Dr. Mikhail Andreev, and Dr. Boris Yurtsev in Bering Land Bridge National Preserve. *Photo by David Murray.*

Peninsula. Approximately 1,000 collections were made. To date, about 70 percent have been identified. The preliminary checklist includes about 230 species; three are new for North America and five are new for Alaska. Several rare and otherwise interesting species for the Seward Peninsula were found and new data on their distribution and ecology were obtained.

Lichens (*M.P. Andreev*)

Time constraints have prevented identification of approximately 1/2 the collection made during 1992. Those identified include the most common species, mostly macrolichens (fruiticose and foliose forms). Much of the unidentified material is of difficult crustose lichens.

At this time the species list totals 218, most of which have been reported previously from Alaska. Because the Seward Peninsula is poorly known lichenologically, 30 species otherwise common in Alaska are reported here as new to the Seward Peninsula. Identified material includes two species new to North America, one species new to Alaska, and nine rare Beringian species.

Comparison of Alaskan And Chukotka Vascular Flora (*B.A. Yurtsev*)

The vascular plant floras of Chukotka and western Alaska are very similar. Of the 480 taxa at the rank of species and subspecies in our preliminary list, fewer than 40 are not found in Chukotka as well. The similarity is especially strong on calcareous habitats such as the Eldorado Creek uplands. The Asiatic component of the Alaskan flora was better defined by 1992 field work that has added about 25 Asiatic taxa to the flora of Alaska.

Research has focused on hypoarctic and arctic-boreal complexes of continental, not oceanic, affinities. A notable exception is the occurrence of halophytic species like *Chenopodium glaucum* (var.*salinum*) and *Puccinellia hauptiana* at Serpentine Hot Spring, but these were confined to the immediate vicinity of the hot spring where various salts had precipitated on the surface of the otherwise bare soil. This pattern is repeated at hot springs on Chukotka. The importance of the continental species decreased with elevation, which was evident in the distribution and local importance of *Rhododendron camtschaticum* subsp. *glandulosum*, *Saxifrage nudicaulis*, and *Luzula beringensis* on the slopes of Mt. Boyan at Kuzitrin Lake.

There is a larger boreal element (*Populus balsamifera*, *P. tremuloides*, *Betula* cf *kenaica*, *Picea glauca*) on the Seward Peninsula than on Chukotka, which is a reflection of the major zonation represented at each locality. The Seward Peninsula is mainly in the southern hypoarctic subzone, whereas Chukotka is primarily in the middle hypoarctic subzone of the tundra. There also was an underrepresentation of arctic and arctic-alpine species (e.g. of the genus *Draba*) even on calcareous substrates.

Traveling by air from south to north on the Peninsula revealed a shift from shrublands and thickets in the south to rolling hills and high terraces covered, for the most part, by tussock tundra, *Eriophorum vaginatum*. In the shrub zones the willow thickets on carbonate landscapes have a parallel in the Chegitun River drainage on the Chukotka Peninsula, and the mixed thickets of willow, shrub birch, and alder on non calcareous areas are similar to those on the coast of the Anadyr estuary and in the Amguema intermmontaine depression.

Generally, the shrub birch thickets, which are so prominent in Alaska, play insignificant roles in adjacent, easternmost Chukotka. The tussock tundra associations have a less diverse herbaceous element in Alaska than in Chukotka; that is, the vascular plant species richness is higher in Chukotka. Extensive surveys near the village of Yanrakynnot have yielded 450 taxa. While the very short surveys in Alaska are not strictly comparable to Yanrakynnot results, nevertheless it is instructive to note the following talleys: Eldorado Uplands (1 day) 140 taxa, Trail Creek (1 day) 170 taxa, Lost Jim Lava Flow (2,000 years old) (1/2 day) 50 taxa, Quartz Creek (3 days) 220 taxa, Serpentine Hot Spring (4 days) 200 taxa.

1993 Fieldwork has just concluded with results similar to 1992, but with fewer "new" findings. One species thought to be rare was found more commonly than expected. Additional material was collected for describing new species. Within a few months, the herbarium at Bering Land Bridge Preserve will be expanded several fold. Lists of species collected by site, and for the park as a whole, will be available. These lists will become part of a larger circumpolar project and will be incorporated into an international database (Allen 1993). New keys are needed immediately to replace the one rendered obsolete with the new data.

There are still areas needing botanical work within Bering Land Bridge National Preserve, and as this work occurs, more species will be found and more range extensions will be noted. For now, we have "finished" a plant inventory in one park unit in Alaska, leaving **only** 53 million acres more to contemplate!

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In the next issue . . .

Editor's Note: Due to the timeliness and length of this month's articles, "Information Crossfile" will not appear in this issue. It will return in the next issue with the stories which were to appear this time plus those for the winter issue – promise!

- "Extended Gap Analysis and NPS Planning" by Gary Machlis and Deborah Forester
- "Ancient Geology of the Columbia River" by Dan Brown
- "BLM's Global Positioning System at Hagerman Fossil Beds" by Chris Force
- "Laughing Gulls at Kennedy Airport" by John Tanacredi
- "Natural Restoration of Black Bears at Big Bend NP" by RickLoBello
- "Evaluating the Effects of Commercial Fishing at Glacier Bay NP" by Philip Hooge
- "Notes from Abroad (China)" by David Ek
- "Integration vs. Separation in Natural and Historic Stewardship" by Ethan Carr
- "Vegetative Aspects of the Olympic NP Goat Report" by Paul Crawford

Commentary on the emerging National Biological Survey has been appearing here and there in print as the concept evolves. Some of the more interesting thoughts, from qualified "thinkers" on the subject are herewith excerpted and presented, together with the source from which they were taken:

From ***Colorado Plateau**, Quarterly Newsletter for Resource Management of Colorado Plateau NPs*, Vol. 3, No. 3, Summer 1993:

"Kilgore [Dr. Bruce Kilgore, Chief of Western Region's Division of Natural Resources and Research] is pleased with the Secretary's commitment to better science and to better service to resource managers by providing a national focus for inventorying and monitoring biological resources, by ensuring that NPS decision makers receive high quality biological information, and by conducting the proactive research needed to avoid conflicts between economic and environmental goals.

"Kilgore encourages Park Service personnel 'to work closely with Denny Fenn, Gene Hester, and the NBS Implementation Team to see that they are successful in achieving these very ambitious goals.'

"Since the NBS proposal is to be implemented through the transfer of NPS and Fish and Wildlife Service research scientists, Kilgore states that 'the Park Service is faced with the challenge to find a way to ensure that the NBS can provide for both the broad strategic research needs of our country's ecosystems, while continuing to serve the immediate, short-range, tactical research needs of Park Service superintendents and other managers.'

"Kilgore also wants to ensure that 'our current NPS scientists and our CPSUs are supported in their new assignment in a way that not only allows them, but encourages them, to finish on-going high priority research projects and to begin a new series of both long-term and short-term I&M research and information transfer to managers.'

"Kilgore continues, 'It's my feeling that our superintendents need to have easy access to the new NBS Coop Units, not unlike the relationship they have developed with our existing CPSUs.'"

* * *

From the statement by Gary E. Davis, Research Marine Biologist, presented at the NBS Eco-Center Meeting, May 3-5, 1993, in Portland, OR:

"To suggest an initial agenda for the NBS, I will identify four broad national trends affecting biotic resources, describe a research agenda to understand and mitigate the negative effects of those trends, and suggest a national focus for these programs to enhance NBS credibility.

Some Additional Thoughts On the NBS

"National attitudes toward natural resources drive all of the trends I will identify. Oddly, the Nation's approach to natural resource-based economic development did not change when the American frontier closed in the 19th Century. We continue to consume resources as if they were inexhaustible, as if we could still go over the next mountain range when we run out of land, but we can't. We live in a **finite** world with **finite** resources, yet we continue to act as if technology would always bail us out, no matter how much we degrade our environment. The rapidly increasing human population in the U.S. that continues to demand more resources per capita from a finite resource base drives trends in biotic resources that require immediate attention to avert economic, social, and environmental catastrophe.

Trends

"1. UNSUSTAINABLE CONSUMPTION OF 'RENEWABLE' RESOURCES drives populations and communities to failure, e.g. serial depletion of coastal fishery stocks and harvest of ancient forests. California's largest coastal fishery is a prime example. In southern California, the diving fishery exhausted stocks of abalone species, one after another, from 1950 to 1980, shifted to red sea urchins in the mid 1970s, expanded into northern California in the late 1980s when stocks declined, and began developing new markets for purple urchins in the early 1990s. This pattern of biotic resource exploitation is common worldwide.

"2. LAND-USE PRACTICES THAT FRAGMENT HABITATS erode society's productive resource base when populations and communities collapse for lack of appropriate space, i.e. critical habitat. Coastal development threatens migratory birds and coastal fisheries with the loss of marshes and estuaries. Loss of large, wide-ranging predators alters community structure and function, thereby accelerating loss of biodiversity.

"3. HUMAN ALTERATIONS OF AIR, WATER, AND SOIL drive ecosystems toward unstable and less productive states, e.g. pollution simplified systems, reduced productivity of contaminated wildlife, ground water extraction, and surface water diversion.

"4. SPREAD OF ALIEN SPECIES causes loss of biodiversity and disrupts ecosystem structure and function. The virtual extinction of native birds on Guam caused by introduced brown tree snakes provides a sobering example of the serious ecological impacts of alien species. Alien species are wreaking havoc on Hawaiian flora and fauna."

Davis's statement asked that the NBS agenda address these trends "with directed programs, not simply collections of related projects." He named five areas of focus needed (1) to lead the exploration of ecological restoration, (2) to develop ecosystem monitoring protocols, (3) to improve understanding of viable populations, (4) to invent ways to predict ecosystem behavior, and (5) to explore adaptive ecosystem management.

"As Machiavelli warned his prince," Davis said, "a new organization that seeks to change established ways of conducting business has few allies. To overcome this handicap, I suggest that the NBS use the National Park System, to focus attention on the nationwide plight of biotic resources... not just to help resolve park issues, but to help realize the potential of national parks to resolve society's broader environmental issues and to produce truly sustainable economic development."

Campfires and Firewood: A Global Perspective

Dick Cunningham is at it again!

The creative, energetic (does this man *ever* sleep?) Chief of Interpretation for the NPS Western Region has produced another small interpretive gem–this time a 6-page piece of resource material for interpreters who want to use the traditional campfire as the centerpiece for a program about firewood.

"I need to strongly emphasize," Cunningham says, "that I am **NOT** advocating the abolishment or the reduction of campfire talks. They are an important part of our interpretive history and will continue to be so. What I do want to discuss for your consideration is the use of firewood on a global basis, its environmental impacts, and the relationship to our campfire programs."

The piece begins with a nod to the "something magical" about staring into a blazing campfire, "listening to the pop of the burning wood," smelling the smoke and perhaps groping our way back via these sensations to an earlier stage of human development when fire represented the center of human life.

Then he describes the results of deforestation and fuel-wood cutting in Africa (6 specific countries), Asia (5 countries), and Latin America (5 countries). Twelve selected references are given for the student who wants more. The result could be a sober reflection of how blessed the United States has been, with the "luxury" to burn wood in our home fireplaces and at park campfires. "There is a strong environmental message here," Cunningham says, "that we interpreters should be personally aware of. I further believe it is a message that should be integrated into our campfire talks."

So perhaps the next time someone says "Ranger, throw another log on the fire," Cunningham suggests the response might be: "That reminds me... I have a story to tell you about firewood."

Dave Mech Receives National Award

Dr. L. David Mech, principal investigator on the Denali Wolf Project, has received the Aldo Leopold Award, given for distinguished service in wildlife conservation – considered by many to be the ultimate recognition of a wildlife professional.

In presenting the award at the North American Wildlife and Natural Resources Conference in Washington, DC in March, Dr. Alan Wentz, president of The Wildlife Society, stated that Mech "stands as testimony that one individual can indeed make a difference in the complex world of conservation and do so without benefit of a large staff. His trademarks are a boundless productive capacity, unswerving dedication, ability to win others to his cause, and above all his willingness to freely work with and exchange views with anyone. He has been called 'the most prominent wolf biologist in the world,' 'dean of wolf researchers,' and 'the alpha wolf.' He has touched practically every wolf project in the world."

The object of this high praise has been overseeing wolf research in Denali since 1986. This research has become one of the most important field studies of wolves and their prey in the world and is providing major insights on the natural functioning of northern wolf/prey systems. Mech's knowledge and enthusiasm has been a driving force behind the efforts of all of us involved in this multi-faceted predator/prey study.

Layne Adams,
Wildlife Research Biologist
Alaska Region

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