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**National Park Service**



OFFICE OF THE CHIEF SCIENTIST  
ANNUAL REPORT  
FOR  
CALENDAR YEAR 1973

NATIONAL PARK SERVICE  
U.S. DEPARTMENT OF THE INTERIOR  
WASHINGTON, D.C.  
July 1974







## FOREWORD

This is the latest report in a series that began in 1968. However, reports for 1970 and 1971 were never compiled and published due to circumstances beyond our control.

The following report is in three parts: 1) a list of science projects underway in the National Park System; 2) narrative progress reports from National Park Service scientists and contractors; 3) a bibliography of reports and publications that pertain to park areas and that were received during 1972.

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## NARRATIVE REPORTS

These are reports of ongoing studies. They are not a part of the scientific literature and should not be quoted without prior consultation with the investigators.



LIST OF SCIENCE PROJECTS  
UNDERWAY IN THE NATIONAL PARK SYSTEM  
DURING 1973

DATA FROM SUPERINTENDENT'S  
ANNUAL RESEARCH REPORTS

## EXPLANATION OF COLUMNS

Column 1: Projects are consecutively numbered for reference purposes in this list only.

Column 2: The RSP number. (All Service-sponsored projects should have one.)

Column 3: Title of Project.

Column 4: Names of Investigators.

Column 5: Organizational Affiliation of Investigators.

### Codes for Columns A, B, and C

Column A: Funding Source

1. NPS Office of Natural Science Studies
2. Other NPS M&P
3. NPS Construction
4. Other Federal Agency
5. State Agency (not university)
6. University, College, Institution
7. Personal

Column B: Personnel

1. NPS
2. Other Federal
3. State Agency
4. University, College, Institution
5. Individual - no affiliation
6. Other

Column C: Status of Project

0. Proposed, but not started because of lack of funds.
1. Proposed, funds available, but not allotted for some reason.
2. Proposed, funds allotted, but actual work not started.
3. Progressing, will continue for indefinite number of FY's.
4. Progressing, will continue for 3 more FY's beginning next July 1.
5. Progressing, will continue for 2 more FY's beginning next July 1.
6. Progressing, will continue for one more FY beginning next July 1.
7. Progressing, expected to be completed prior to next July 1.
8. Field work complete, final report not submitted.
9. Field work complete, final report in, awaiting approval.
10. Project completed, including approval of final report.

Page: Page number refers to where report appears in the Narrative Report section.

## ABBREVIATIONS

NPS: National Park Service - usually followed by one of the following:

Collab: Collaborator  
CPN: Chief Park Naturalist  
RB: Research Biologist  
MB: Management Biologist

### Organizational Affiliations

Acad Academy  
ADF&G Alaska Dept Fish and Game  
Agri Agriculture  
Ak Alaska  
Am American  
Aud Audubon  
Bio, Biol Biology, Biological  
BLM Bureau of Land Management  
Bot Botanical  
Br British  
BSCS Biological Sciences Curriculum Study  
BSFW Bureau of Sport Fisheries & Wildlife  
Bur Bureau  
C College  
CA California  
CDA California Department of Agriculture  
CDFA California Department of Food & Agriculture  
CDFG California Department of Fish & Game  
Co Company  
Comm Community, Commission  
Coop Cooperative  
Corp Corporation  
Cons Conservation  
CRF Cave Research Foundation  
Ctr Center  
Dept Department  
Des Desert  
Dev Development  
Div Division  
Ecol Ecological  
Eng Engineer  
Env Environmental  
Expl Explorer  
F&G Fish and Game  
Fdn Foundation  
For Forest  
Geog Geographical  
Geol Geology, Geologic, Geological  
GLBA Glacier Bay National Monument  
Hist History  
Inst Institute, Institution  
Lab Laboratory  
Mgt Management  
MTU Michigan Technological University  
Mus Museum  
NASA National Aeronautics and Space Administration  
Nat National, natural  
NHCUC New Hampshire College and University Council

NM	National Monument
NMNH	National Museum of Natural History
No	North
NPS	National Park Service
NRA	National Recreation Area
NRC	National Research Council
NSF	National Science Foundation
NSS	National Speleological Society
Obs	Observatory
Poly	Polytechnic
PSWFRES	Pacific Southwest Forest and Range Experiment Station
Reg	Region
Res	Research
Sch	School
Sci	Science
SCS	Soil Conservation Service
Serv	Service
So	South, Southern
Soc	Society
St	State
SUNY	State University of New York
SW	Southwest
Tech	Technology
U	University
UC	University of California
UCLA	University of California, Los Angeles
USBSFW	U.S. Bureau of Sport Fisheries and Wildlife
USDA	U.S. Department of Agriculture
USFS	U.S. Forest Service
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Service
W	West, Western
Wildl	Wildlife

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BADL - BADLANDS NATIONAL MONUMENT, SOUTH DAKOTA								
1	Ecology of Prairie Deer in SD	Severson Carter	USFS SD Game Fish & Parks	1,4 & 5	2,3	3		
2	Paleontological Explorations	R Coomber	Coffman Jr HS	6	4			
3	Paleontological Excavations	F Hooper	Raymond Alf Mus	6	4			
4	Loess Deposits	J P Briggs	SD Sch Mines	7	4			
5	Micro fossil Screening	T Riedel	Cleveland Mus Nat Hist	6	4			
6	Prairie Dog Food Habits Study	C Sorenson	SD St U	6	4			
7	Rattlesnake Parasitology	R Schuurmans	SD St U	7	4			
8	Soil Samples - Paleomagnetic Studies	J Martin	SD Sch Mines	6	4			
9	Entomology Teaching Specimens	J Wright	Alpena C, Michigan	6	4			
10	Streambed Rock & Soil Samples	N Salisbury	U Iowa	6	4			
BAND - BANDELIER NATIONAL MONUMENT, NEW MEXICO								
11	Herpetofaunal Survey of Bandelier	W G Deganhardt J S Jacob S R Williams	U New Mexico	1	4	7	3	
12	Ecological Study of Feral Burro Impact	D Koehler L D Potter	U New Mexico	1	4	8	3	
13	Decline of Alligator Bark Juniper in Bandelier National Monument	J R Gosz G Mark	U New Mexico	1	4	8	3	
BIBE - BIG BEND NATIONAL PARK, TEXAS								
14	N-8 Reestablishment of Harlequin Quail in Big Bend NP	R H Wauer		1	1	5	11	
15	N-3A Ecology of the Carmen Whitetail Deer	P R Krausman	U Idaho	6	4	7	10	
16	N-9A Behavioral Ecology of the Collared Peccary	J A Bissonnette	U Michigan	6	4	7	11	
17	N-18 Field Study and Survey of Chiroptera in Big Bend NP	D A Easterla	Northwest Missouri St U	7	4	5	12	
18	N-31 Ants of the Chisos Mountains, Texas	A Van Pelt	Greensboro C	6	4	7	12	
19	N-33 Winter and Spring Movements of Coyotes in Big Bend NP	D Stine J F Scudday	Sul Ross U	4,6	2,4	7	13	
20	N-34 Mountain Lion Study	R McBride	Welder Wildlife Fdn	6	4	6	13	

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BIBE - BIG BEND NATIONAL PARK, TEXAS (continued)								
21	Chiggers of Big Bend NP	W Wrenn	U North Dakota	6	4	8		
22	Basic Biological Research on Lepidoptera of Big Bend NP	R O Kendall	San Antonio, Tx	7	4	3	8	
23	Petrographic Study of Alkaline Igneous Rocks of Big Bend NP	M Carman	U Houston	6	4	3	9	
24	Study of the Moths of Texas	A Blanchard	Houston, Tx	7	4	3	8	
25	Land Snails of Trans-Pecos	E P Cheatum	Dallas Mus Nat Hist	6	4	3		
26	Bryophytes of Big Bend NP	W F Mahler	Southern Methodist U	6	4	3		
27	Physiology of Desert Invertebrates	C S Crawford	U New Mexico	6	4	8	5	
28	Mercury Study in Terlingua Creek & Rio Grande Areas of Big Bend NP	J G Houston	Sul Ross U	1,6	4	5	9	
29	Limnology Study of Aquatic Resources, RGV, Big Bend NP	O T Lind	Baylor U	1,6	4	6		
30	Determination of Mercury Concentration in Lizards	D Gallagher	Sul Ross U	6	4	6		
31	Ethological Study of <i>Vermivora crissalis</i> in Chisos Mountains, Texas	S Robinson	Sul Ross U	7	4	10	9	
BICA - BIGHORN CANYON NATIONAL RECREATION AREA, MONTANA								
32	Limnology of Yellowtail Reservoir & Bighorn River	J C Wright	Montana St U	4	4	10	14	
33	Yellowtail Reservoir and Bighorn River Post-Impound-ment Surveys (Fisheries)	S E Swedberg	Montana Fish & Game Dept.	5	3	6		
34	Creel Census and Growth & Movement Study of Trout in the Bighorn River	H Stevenson	Montana U	7	4	8	14	
35	Waterfowl Distribution and Population Study	J Denton	Montana Fish & Game Dept	5	3	6		
36	Evaluation of Changes in Land Use Relative to Pheasant Habitat	J Denton	Montana Fish & Game Dept	5	3	8		
37	Investigation of Conflicts Among Recreation Users of the Bighorn River	J Denton	Montana Fish & Game Dept	5	3	6		
38	Upland and Big Game Inventory of the Pryor Mountains & Beartooth Plateau	J Denton	Montana Fish & Game Dept	5	3	6		

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BISC - BISCAYNE NATIONAL MONUMENT, FLORIDA								
39	N-3	Coral Reef Ecology	G E Davis L L Purkerson	NPS	1	1	3	15
40	N-4	Reef Fish Ecology and Population Dynamics	G E Davis	NPS	1	1	3	15
41	N-11	Boat Traffic and Turbidity	L L Purkerson	NPS	1	1	3	
42	N-12	Disrupted Flow and Degredation of Fresh Water Inflow	L L Purkerson	NPS	1	1	3	
43	N-2	Ecology of <i>Sciurus aureogaster</i> on Elliott Key	R McGuire, Jr		6	4	10	
44	N-7	Comparison of Manmade and Natural Reefs	Pratt Stone		4	2	7	
45	N-8	Marine Survey, Old Rhodes Lagoon	R Holm	Northwestern U	6	4	5	15
46		Radiation Pollution Monitoring	Matarrese	St Florida				
47		Marine Fish and Invertebrates for Museum	Brown	Mus Sci, Miami				
48		Dredge-Fill and Water Clarity	Griffin	Harbor Branch Fdn Lab				
49		Growth Rates of Gorgonians	Bayer	U Miami				
50		Insect Study	Covell	U Louisville				
51		Quarterly Coastal Vegetation Survey	Carlton	Florida Dept Nat Resources				
BLRI - BLUE RIDGE PARKWAY, VIRGINIA - NORTH CAROLINA								
52		Plants	D C Bliss	Randolph-Macon Woman's C		4	3	
53		Geology of the Marion and Little Switzerland Quadrangles, North Carolina	J R Butler	U No Carolina	5	4	3	22
54		Practicum in Training of Inter- pretive Naturalists Using the Blue Ridge Parkway as a Learning Laboratory	I W Carpenter	Appalachian St U	6	4	3	25
55		Geology of Skyland-Dunsmore Quadrangles	A E Dabbagh	U No Carolina	5	4	7	21
56		Petrology of Shortt's Knob Area, Floyd County, Virginia	D Davison, Jr	Va Poly Inst & St U				
57		Aquatic Life, Sim's Pond	F R Derrick	Appalachian St U	6	4	3	
58		A Microlichen Flora of the High-Mountain Areas above 5,500 Feet in the Southern Appalachians	J P Dey	Duke U	6	4	6	26
59		Aquatic Insects	O S Flint, Jr	Smithsonian Inst				

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BLRI - BLUE RIDGE PARKWAY, VIRGINIA - NORTH CAROLINA (continued)								
60	Floristics of Central Virginia Blue Ridge	R S Freer	Lynchburg C	6	4	4	4	21
61	Rocks & Minerals	B E Gushee	Hollins C					
62	Oil Bodies of Some Southern Appalachian Leafy Liverworts	M L Hicks	U Tenn					
63	Systematics of Plethodontid Salamanders	R Highton	U Maryland	4	4	4	4	21
64	Gypsy Moth Survey - Trapping	W D Jones	USDA	4	2	8	22	
65	Amphibians and Reptiles of Southwest Virginia	H G Jopson	Bridgewater C	7	4	6		
66	Genetics of Isolated & Non-Isolated Populations of the Mountain Salamander, <i>Desmognathus ochrophaeus</i>	C O McKinney S C Tilley	U Dayton Smith C	6	4	8	29	
67	A Biosystematic Study of <i>Calystegia spithameacates-beiana</i> Complex	P B Mikesell	Penn St U	7	4	7	22	
68	Collect Twigs & Buds & Leaves	F H Miller		7	5	6	23	
69	Plants	T A Moore	Va Poly Inst					
70	Plants - Ferns and Liverworts Herbarium Collection	C Morlang, Jr	Hollins C	7	4	3	24	
71	Structure & Development of Haustorium, Parasitic Scrophulariaceae	L J Musselman	U No Carolina	7	4	3		
72	Study & collection of salamanders, nongame fishes, and other nongame, small vertebrates	L M Outten	Mars Hill C	7	4	3	29	
73	Vegetation in a Burned Area, Pisgah National Forest, Haywood County, North Carolina	W T Penfound	Warren Wilson C	6	4	7	18	
74	Vascular Flora of the Carolinas	J D Pittillo	W Carolina U	7	4	3	24	
75	Ecological-Floristics of the Central Virginia Blue Ridge Mountains & Study of Unusual Vascular Epiphytes	G W Ramsey	Lynchburg C	6	4	5	17	
76	Studies of <i>Cryptocercus punctulatus</i> hind-gut protozoa	H Ritter, Jr	U Georgia	6	4	3	17	
77	Leaves, Soil	S B Reynolds	Mars Hill C		4			
78	Preserved & Herbarium Plant Specimens	K R Robertson	Harvard U					
79	Population Genetics of <i>Trillium taxa</i> ; Bio-Systematic Study	C A Serota	Mars Hill C					

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80	Location and Sampling of Unusual Rhododendron	F W Shield			7	5	3	
81	Studies on Terrestrial Invertebrates of North Carolina	R M Shelley	No Carolina St Mus		7	3	3	26
82	Aphididae of North America	C F Smith	No Carolina St U		7	4	3	27
83	Geological Investigation of the Northwest Flank of the Blue Ridge	E W Spencer	Washington & Lee U		6	4	3	24
84	Undergraduate Biology Class (Upper Class Level) Field Studies	D L Stockdale	Warren Wilson C		6	4	3	20
85	Ferrum College Environmental Education Center	J D Stogner	Ferrum C			4	3	
86	Collection of Dominant Vascular Plants & Bryophytes	J R Taylor	Mars Hill C		6	4	3	16
87	Ecology of Populations of the Salamander <i>Desmognathus ochrophaeus</i>	S G Tilley	Smith C		6	4	3	18
88	Study of Comparative Behavior & Ecology of Insects, Order Mecoptera	A R Thornhill	U Michigan		6	4		
89	Analysis of the Late-Blooming Form of <i>Rhododendron calendulaceum</i>	F F Willingham, Jr	Wake Forest U		7	4	10	23
90	General Collection for Identification Purposes	J W Yelton	Brevard C		7	4	3	
91	Flora of Sims Pond Area	M Livengood l W Carpenter						25
92	Phytoecology of Boone Fork Sphagnum Bog	T A Moore J F Randall						26
BRCA - BRYCE CANYON NATIONAL PARK, UTAH								
93	Basic Processes of Erosion Rates of Cliff Recession & Denudation of Land	R F Hadley	USGS		4	2	4	
94	Changing Conditions and Trends of Forest Communities of Bryce Canyon	H Buchanan	Weber St U		4	4	6	
95	Nesting Birds in a Yellow Pine Forest, Bryce Canyon NP	R H Gerstenberg	Reedly C		7	1	4	30

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BUFF - BUFFALO NATIONAL RIVER, ARKANSAS								
96		Preliminary Reconnaissance Water Quality Survey of Buffalo National River		Arkansas Water Resources Res Ctr	1,6	4	9	30
CANY - CANYONLANDS NATIONAL PARK								
97	N-4	Plant Synecology of Canyon- lands NP	W L Loope	Utah St U	6,7	4,6	8	31
98	N-6	Mammalian Faunal Relationship of Canyonlands NP	D M Armstrong	U Colo	6,7	4	6	32
99	N-7	Visitor Impact in Cateract Canyon (River Use on Green & Colorado River)	J Hunt	Utah St U	6	1,4	5	33
100		Survey of Natural Rock Openings in Southern Utah	D J Stevens	Brigham Young U	7	4	8	
CACA - CARLSBAD CAVERNS NATIONAL PARK, NEW MEXICO								
101	N-1a	Cave Climate	J S McLean	USGS	1	2,1	8	38
102	N-6a	Location of Caves-Part D Ground Reconnaissance	C M Peterson	NPS	2	1	4	40
103	N-11a	Natural Ecologic Surface Conditions-Part A Wildfire	G M Ahlstrand	NPS	2	1	4	41
104	N-12	Park Surface Ecosystems Map Browse Range Analysis Survey	R Reisch M Glass	NPS	2	1	8	41
105	N-13	Population Dynamics of Mexican Freetail Bat	J S Altenbach K N Geluso D E Wilson	U New Mexico NMNH	1,6	4	5	
106		Air Pollution from Bird Nesting in Cave	G M Ahlstrand	NPS	1,2	1		38
107	N-2	Study of Cave Invertebrates	W R Elliott	Texas Tech	7	4	6	
108	N-2	Study of Cave Invertebrates <i>Ceuthophilus</i> Activity Rhythms	G D Campbell	Texas Tech & Cave Res Fdn	7	4	6	39
109	N-5	Cave Mapping		Cave Res Fdn	7,6	4	3	
110	N-6a	Location of Caves-Part A Gravity Survey		Cave Res Fdn	7	4	3	39
111	N-9	Rock Stress Studies in Cave	J S McLean	USGS	7	2,1	8	40
112		Microorganism Survey in Soil and Debris from Carlsbad Caverns	D E Gardner					38
CHCA - CHACO CANYON NATIONAL MONUMENT, NEW MEXICO								
113		Physical Geography of Chaco Canyon	R Snead	U New Mexico	2	4	8	

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CHCA - CHACO CANYON NATIONAL MONUMENT, NEW MEXICO (continued)								
114		Palynological Studies	S A Hall	U Michigan	2	4	8	
115		Recent Geology	H Maulde	USGS	4	2	3	
116		Feasibility of Remote Sensing in Resource Management	W J Judge	U New Mexico	4	4	7	
117		Upper Cretaceous Geology	C T Siemerz	U New Mexico	2	4	8	
118		Acquisition and Digitization of Archeological Data	Koogle & Pouls Eng		4	6	7	
119		Ecological Survey of Chaco Canyon Area	L Potter	U New Mexico	2	4	8	
120		Planimetric Mapping of Chaco Ruins	Koogle & Pouls Eng		4	6	10	
121		Hydrology of Chaco Canyon National Monument Area	G Moore					43
CHIS - CHANNEL ISLANDS NATIONAL MONUMENT, CALIFORNIA								
122	N-100	Natural Resource Plan Research Basic Data - Archeology	C Rozaire	LA County Mus	1	4	8	
123		Natural Resource Plan Research Basic Data - Geology	D Weaver	UC, Santa Barbara	1	4	10	
124	N-7	Celestial Orientation of Talatrid Amphipods	R F Hartwick	UC, Scripps Inst	6	4	3	
125	N-8	Behavioral Ecology of Nesting <i>Larus occidentalis</i>	G L Hunt	UC, Irving	6	4	10	
126	N-9	Evolutionary Relationships of Channel Island Mammals	D K Odell J P Waggoner	UCLA	6	4	6	
127	N-10	Rodent Survey on Santa Barbara and Anacapa	R E Main	Oregon St U	6	4	6	
128		Survey of Land Birds Channel Islands	J Diamond L Jones	UCLA	6	4	7	
129		Elephant Seal Migration Studies - San Miguel Island	B J LeBoeuf	UC, Santa Cruz	6	4	3	
130		Spiders of Anacapa	D Marqua M Thompson	UCLA	6	4	3	
131		Coreopsis Propagation	R Utterback et al	LA County	6	4	3	
132		Flora of Channel Islands	R Philbrick	Santa Barbara Botanic Gardens	6	4	3	
133		Grasshoppers of Channel Islands	D Weisman	Stanford U	6	4	8	
134		Brown Pelican Study		USFWS, NPS	5	5	3	

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135		North American Fur Seal Study	R L DeLong	Dept Commerce	2	2	7	
CHIR - CHIRICAHUA NATIONAL MONUMENT, NEW MEXICO								
136		Ecology of the Coati	D Lanning	Evergreen St C	6	4	7	45
137		Geology in Chiricahua New Mexico	R P Yetman	Chiricahua NM	2	1	7	44
138		Research Natural Areas of Chiricahua National Monument	W Moir	Ariz Acad Sci	5	5	10	44
CRLA - CRATER LAKE NATIONAL PARK, OREGON								
139	N-2A	Black Bear Study	M McCollum J Blaisdell	NPS	1	1	6	46
140	N-15A	Elk, Their Ecology and Management	M McCollum J Blaisdell	NPS	1	1	3	48
141	N-13	Vegetation Dynamics, Ponderosa Pine	D Zobel R McNeil	Oregon St U	1	4	6	
142	N-6	Water Resources Appraisal	D D Harris	USGS	4	2	3	47
143	N-8	Small Mammal Disease Survey	R Gresbrink	Oregon St U	5	3	3	47
144	N-11	Balsam Woolly Aphid Study	R Mitchell	USFS	4	2	3	
145		Biosystematics of <i>Ranunculus eschscholtzii</i>	A Hawryski		6	4	3	
146		Glacial and Volcanic Geologic Features	J H Hyde	USGS Tacoma Community C	4,6	2,4	3	
147		Temperature Profiles in Crater Lake	V Neal	Oregon St U	4,6	4	3	
CRMO - CRATERS OF THE MOON, NEW MEXICO								
148		Study of Accessory Minerals in Primary Volcanic Rocks	W O Romey W T Elberty, Jr	St Lawrence U	4	4	8	49
149		Magnetic Secular Variation of Great Rift Basalts	D E Champion E Shoemaker	CA Inst Tech	7	4	6	49
150		Oxygen Isotope Geochemistry of Basalts from Snake River Plain	K Muehlenbacks G Stone	Geophysical Lab, Wash D C U Oklahoma	6	4	6	49
CURG - CURECANTI GROUP, COLORADO								
151	N-3a	Porcupine Study	R Benton	NPS	1	1	3	
152	N-118	BLCA Archeological Survey		U Colorado	1	4	6	

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153		Rocks	R W Pierce	U Florida	7	4	8	
154		Grasshoppers	R B Willey	U Illinois	7	4	3	
155		Identify Birds	A S Hyde	NPS	7	5	3	
156		Common Deer Mouse <i>Peromyscus maniculatus</i>	L R G Snyder	Stanford U Rocky Mt Bio Lab	6	5		
DEVA - DEATH VALLEY NATIONAL MONUMENT, CALIFORNIA								
157	N-5	Mortality of Desert Holly	C L Douglas	NPS	1	1,4	5	62
158	N-10	Bighorn Ecology	C L Douglas	NPS	1	1	3	62
159	N-11	Burro Activity Evaluation	C L Douglas	NPS	1	1,4	4	62
160	N-12	Basic Ecological Reconnaissance	C G Hansen	NPS	1	1	10	
161	N-13	Hydrological Survey of Death Valley	G A Miller	USGS	1	2		
162	N-15	Social Behavior & Ecology of Feral Burros	P D Moehlman	U Wisconsin	4,6	4	8	
163	N-16	Natural History Inventory Scotty's Castle & Ranch	C L Douglas	NPS	1	1	2	
164	N-17A	Food Utilization of <i>Cyprinodon nevadensis</i>	J E Deacon	U Nevada, Las Vegas	6	2		
165	N-17B	Marsh Vegetation, Saratoga Springs	W G Bradley	U Nevada, Las Vegas	6	2		
166		Salinity Tolerance & Blood Properties of Pupfishes	R Naiman	Arizona St U		4		
167		Thermal Environment of a Death Valley Pupfish	R Naiman	Arizona St U	4	4	10	
168		Physiology of Man in Extreme Heat	D B Dill	U Nevada Desert Res Inst	4	4	3	50
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UNIVERSITY OF ALASKA  
COOPERATIVE PARK STUDIES

INVESTIGATOR: Frederick C. Dean

SUMMARY OF  
PROGRESS: The Alaska Cooperative Park Studies Unit was established in mid-1972 consequently, calendar year 1973 represents a slice through the latter part of the first 18 months of its life. The Unit Leader, Frederick C. Dean, is professor of wildlife management of the University of Alaska and is under contract through the University to the National Park Service. Activities during 1973 were largely extensions of projects begun during 1972. During the year most of the work centered in Mt. McKinley National Park or was related to its ecology. The ecological survey of the north boundary and the lands that may be added to the north side of the park continued, with several flights made in late winter, spring, and early fall. A series of color photographs was taken in early September in order to provide calibration for the interpretation of black and white photographs or ERTS imagery. The design of the formal sampling scheme has been delayed until a set of photographic prints can be acquired for use in Fairbanks, but plans for 1974 include a statistically designed survey of much of the region adjacent to the north boundary of the park.

The project on the ecology of scavengers, begun in 1972, was continued during the course of a biological survey of the north fork of the Canning River. Graduate students Magoun and Valkenburg were conducting the Marsh Fork survey under contract to the Bureau of Sport Fisheries and Wildlife as a follow-up on work that they did just east of the Canning River in 1972. During the course of this, they were able to make observations on the utilization of one collected specimen and several natural kills. The absence of caribou from the Marsh Fork during the summer of 1973 precluded more extensive collecting. The 1972 data on the activity of bears, wolves, ravens, and other scavengers seen at the 11 carcasses are now on computer tape and are being analyzed with a series of programs that will permit sorting, tallying, and checking time and sequence of activities. The relatively small amount of new data gathered in 1973 will be added to the file. Magoun's thesis covering this project should be completed in May 1974. In May 1973, graduate student Tracy began work on the project designed to assess the impact of traffic on wildlife. Her objectives include a measurement of the reaction of animals under varying conditions of disturbance arising from vehicles and people along the road. She was assisted in the project by Bowdy Train and Harold Downing. Three pairs of plots, including one plot along the road and a comparable one off the road, were surveyed five times during the summer and the shuttle buses were ridden several times a week, depending upon sampling schedule. Observations made from the buses should yield considerable information on the numbers of animals seen from the road and their reactions to varying amounts of disturbance. A series of observational transects was driven by Tracy and Dean for comparison with the bus information. Information from all sources will be compared over time and across substantial changes in traffic levels in the park. However, there are enough complex variables that were associated with the problem so that we are still forced to look at our approach as an experimental one. Hopefully, it will prove sensitive enough to make the measurement of some reactions possible. The substantial number of observations precludes any analysis that does not utilize computer sorting techniques. The data are currently being coded, and the analysis process is well into the design stage.

Graduate student Whitten continued his work on sheep range relationships; the unit supported him with a small amount of logistical aid. He worked in the park through the summer, following sheep and observing the feeding behavior in relation to the condition of vegetation. He has continued to make periodic trips to the north boundary area during the winter.

More general activities of the Cooperative Park Studies Unit included the appointment of National Park Service biologist Dr. John G. Dennis as Adjunct Assistant Professor at the University of Alaska. Unit Leader Dean and several of his students spent most of

one week in August working with the Mt. McKinley National Park staff in a research planning session. The computerized bibliographic file of references dealing with Mt. McKinley National Park is being added to slowly; the wildlife observation data file received extensive effort during 1973 and includes the majority of the published observations plus those from a number of persons' unpublished field books. However, this file will remain only partially useful until some of the substantial bodies of information that do exist can be incorporated into it. A map of Mt. McKinley National Park on a scale of 1:250,000 has been computerized. This map can be used for plotting information from the wildlife observation data file or from the University of Alaska Herbarium which is coding all of its accessions in computer format. Input to the map must be in the form of latitude and longitude coordinates. We expect to be able to use this map in showing plots of seasonal distributions and shifts of various animals, collection sites of plants, etc. The unit provided supervisory cover for three additional major projects: the Dixon Harbor Biological Survey (Glacier Bay National Monument); the Gates of the Arctic vegetation survey (Brooks Range, Alaska Task Force); and the Chukchi-Imuruk Biological Survey (Seward Peninsula, Alaska Task Force).

In view of the fact that the unit only began work on the several projects it is engaged in during the 1972 field season at the earliest, there are no substantial results to report at this time. However, the scavenger project should be completed by late spring 1974, as noted above, and a first-year report should be available at that time on the impact study.

## ARCHES NATIONAL PARK

### NATIONAL ROCK OPENINGS IN SOUTHEAST UTAH

INVESTIGATOR: Dale J. Stevens  
Brigham Young University

SUMMARY OF  
PROGRESS: Enough field data have been collected to evaluate the nature and geographical pattern of natural openings (arches, bridges, etc.) in Southeast Utah. A classification of these openings has been formulated, but refinement is still in progress. A complete cataloging of all openings in Arches National Park requires further field work. This aspect is approximately 90% complete. A booklet is presently being written which should have general interest to visitors traveling in southeast Utah.

# BANDELIER NATIONAL MONUMENT

## ECOLOGICAL STUDY OF FERAL BURRO IMPACT IN BANDELIER NATIONAL MONUMENT

INVESTIGATORS: Loren D. Potter) University of New Mexico  
David Koehler )

SUMMARY OF It is inappropriate to file an annual report of this project at this time.  
PROGRESS: The initial funding was delayed beyond all promises. Graduate students  
at the end of a school year did considerable work and invested personal  
funds with no reimbursement for a delayed period.

On 17 July 1973, a preliminary reconnaissance report was requested and turned in by David Koehler. During the balance of the summer season, field work was completed for a vegetational type map by use of aerial photographs and checking on the ground. Types are designated by the dominant species. Trend of condition was also indicated. Representative areas were sampled by the use of transects.

The basic vegetational map with types and trends has been cartographically completed -- but the cost of the student cartographer not as yet reimbursed due to the delay in transferring funds to the university.

Observations of burro habits, movements, feeding, and damage were continued during the field season. On-site visits have been made by the principal investigator with some photography completed, but more is to be done. Any continued work depends upon the availability of funds.

# # #

## ALLIGATOR BARK JUNIPER STUDY IN BANDELIER NATIONAL MONUMENT

INVESTIGATORS: James R. Gosz) University of New Mexico  
Graham Mark )

SUMMARY OF The progress of this study has been hampered by a lack of funds and  
PROGRESS: delay in receiving those that were available.  
A census has been made of the density and location of stands of Alligator  
Bark Juniper. Data also have been taken on size distribution, seed production, and seed  
viability for various stands in the park. An attempt is being made to age individuals to  
identify the age structure of the population. This will tell us a great deal about the  
reproductive strategy of the species.

# # #

## A HERPETOFAUNAL SURVEY OF BANDELIER NATIONAL MONUMENT

INVESTIGATORS: William G. Degenhardt) Museum of Southwestern Biology  
James S. Jacob ) University of New Mexico  
S. R. Williams )

SUMMARY OF PROGRESS: A survey of the herpetofauna of Bandelier National Monument was undertaken and completed during the summer of 1973. The survey analyzed relative abundance and habitat preference as well as elevation and geographic distribution.

Thirteen species were found to occur within the monument's boundaries. *Plethodon Neomexicanis*, the Jemez Mt. Salamander, whose range extends near the monument, was not found within Bandelier. It is, however, possible that during an extremely wet year, the animal may move into the extreme upper portion of Frijoles Canyon.

The final report will be submitted to the National Park Service within the next few months, thereby completing the project. It is, however, hoped that if any new species are found within Bandelier National Monument, the Division of Herpetology of the Museum of Southwestern Biology will be notified. This will allow us to aid in identification and offer any recommendations that might be warranted.

## BIG BEND NATIONAL PARK

### WATER RESOURCES OF BIG BEND NATIONAL PARK

INVESTIGATOR: E. R. Leggat  
U.S. Geological Survey - Contract

OBJECTIVES: To determine the available sources of water for Big Bend National Park, with particular emphasis on the potential of the ground-water supplies.

METHODS: The investigation of the water resources was divided into three phases: the first consisted of a complete inventory of all the sources of water and the relationship between these sources and the geology; the second consisted of a test drilling program with emphasis on areas of greatest need; and the third consisted of a comprehensive report evaluating in particular the potential of the ground-water resources to supply the water needs of the park.

RESULTS: Inventoried all sources of water, drilled 15 test holes, and pump tested three exploratory wells. The three wells tested had a potential production of about 150 gpm or 215,000 gpd, which is more than five times the 1970 water use at the headquarters and the basin.

In 1972, a study was made to determine relationship between precipitation in the Chisos Basin and the flow of Oak Spring and Cattail Falls and the availability of underflow in the major streams that drain the Oak Springs area. No underflow was found and data were too sparse to evaluate fully the relationship of spring flow to precipitation.

A 6-inch test well was drilled by contract from surface to a depth of 3470 ft below land surface. Elevation of bottom of hole is -170 ft msl. The hole was geophysically logged (caliper, resistivity, spontaneous potential, gamma, and neutron). Drill-cutting samples were analyzed by Dr. Ross Maxwell.

Early determinations indicate the test hole is bottomed in the Penn formation of Cretaceous Age. Water was encountered in the Chisos and Javelina formations (325 ft deep, estimated yield 25 gpm) and in the Aguya Formation (2000 ft deep, estimated yield less than 5 gpm).

CONCLUSIONS: The test well is not capable of supplying the minimum desirable water requirements for the proposed Ceniza development.

PLANS FOR 1974: Drill 1000 ft deeper to the Georgetown limestone (3900-4200 ft below land surface) near the K-Bar Ranch and continue the collection of basic data.

Bibliography:

- Garza, S. 1966. Results of Phase I, water resource investigations, Big Bend National Park, Texas. U.S. Geological Survey memorandum report.
- Leggat, E. R., R. D. Reeves, and C. R. Follett. 1968. Results of water-resources investigation of the Big Bend National Park, Phase II. U.S. Geological Survey administrative report, 15 p., 1 fig.
- Leggat, E. R. 1971. Results of aquifer tests at Big Bend National Park, Texas. U.S. Geological Survey memorandum report, 5 p., 3 figs.
- Leggat, E. R. 1972. Relationship between precipitation in the Chisos Basin and the flow of Oak Spring and Cattail Falls. U.S. Geological Survey letter report.

# # #

### PHYSIOLOGY OF DESERT INVERTEBRATES

INVESTIGATOR: Clifford S. Crawford  
The University of New Mexico

SUMMARY OF PROGRESS: This year my work has emphasized the objectives of a project funded by IBP: The role of the desert millipede *Orthoporus ornatus* in a desert ecosystem. It has been a complex study in which ecological and physiological information from three populations (two in New Mexico) has been applied to demographic data obtained at Big Bend National Park. Big Bend research entailed mainly extraction between 23 May and 21 June of all specimens from three, 929 m<sup>2</sup> enclosure plots set up near the bridge over Upper Tornillo Creek. Many field observations and microhabitat temperature measurements were also made. Vegetative cover was measured in the three plots.

Average plot cover was 16%. Millipede counts and plant diversity are given in Tables 1 and 2. Extrapolated to a hectare basis (1 hectare = 2.48 acres) and corrected for presumed millipedes present but never collected and for very young specimens, this comes to about 1500 specimens per hectare.

If my bimodal frequency distributions of size classes (Fig. 1) are typical of the Tornillo Flat *O. ornatus* population, then several years ago there may have been high mortality, low natality, little growth, or some combination of these. Longevity of nearly a decade is suspected.

Several summarized conclusions from calculations being submitted in an annual report to IBP are given below and will be of interest to the NPS. They apply only to the 1973 study at Tornillo Flat, and are "best estimates" based on much investigation and certain assumptions.

- (i) Millipede dry weight biomass per hectare = 3295 g or 7.3 lb.
- (ii) Millipedes at Tornillo Flat consumed an estimated total annual weight of 5372 g or 11.8 lb per hectare. These values are of ash-free, dry weights of mainly dead vegetation. They would come to about half the value of the "live weight" of the material consumed.
- (iii) The same millipedes produced an estimated ash-free, dry weight total of 4039 g or 8.9 lb of feces per hectare in 1973.

TABLE 1. Plant cover and diversity, and *O. ornatus* density in three, 929 m<sup>2</sup> enclosure plots at Tornillo Flat between 23 May and 21 June 1973.

Plot	Ground cover (%)	No. of plant species exceeding 1% cover	No. of <i>O. ornatus</i> >1mm midseg. width	Estimate of <i>O. ornatus</i> density ha <sup>-1</sup>
North	20	8	170	1830
South	4	2	91	980
West	23	3	102	1098

$$\bar{x} = 1303 \text{ ha}^{-1}$$

TABLE 2. Ground cover of all vegetation in three, 929 m<sup>2</sup> plots at Tornillo Flat, May 1973.

Species	North plot	South plot	West plot
<i>Larrea divaricata</i>	10	2	17
<i>Fouquieria splendens</i>	1	-	-
<i>Opuntia leptocaulis</i>	1	-	4
<i>Mimosa biuncifera</i>	2	-	-
<i>Aloysia lycioides</i>	2	-	-
<i>Yucca torreyi</i>	1	-	-
Grass clumps	1	-	-
All other plants <sup>a</sup>	2	2	2
Totals	20	4	23

<sup>a</sup>Among species with less than 1% cover: *Prosopis glandulosa*, *Echinocereus enneacanthus*, *Gutierrezia* sp., grasses, and annuals.

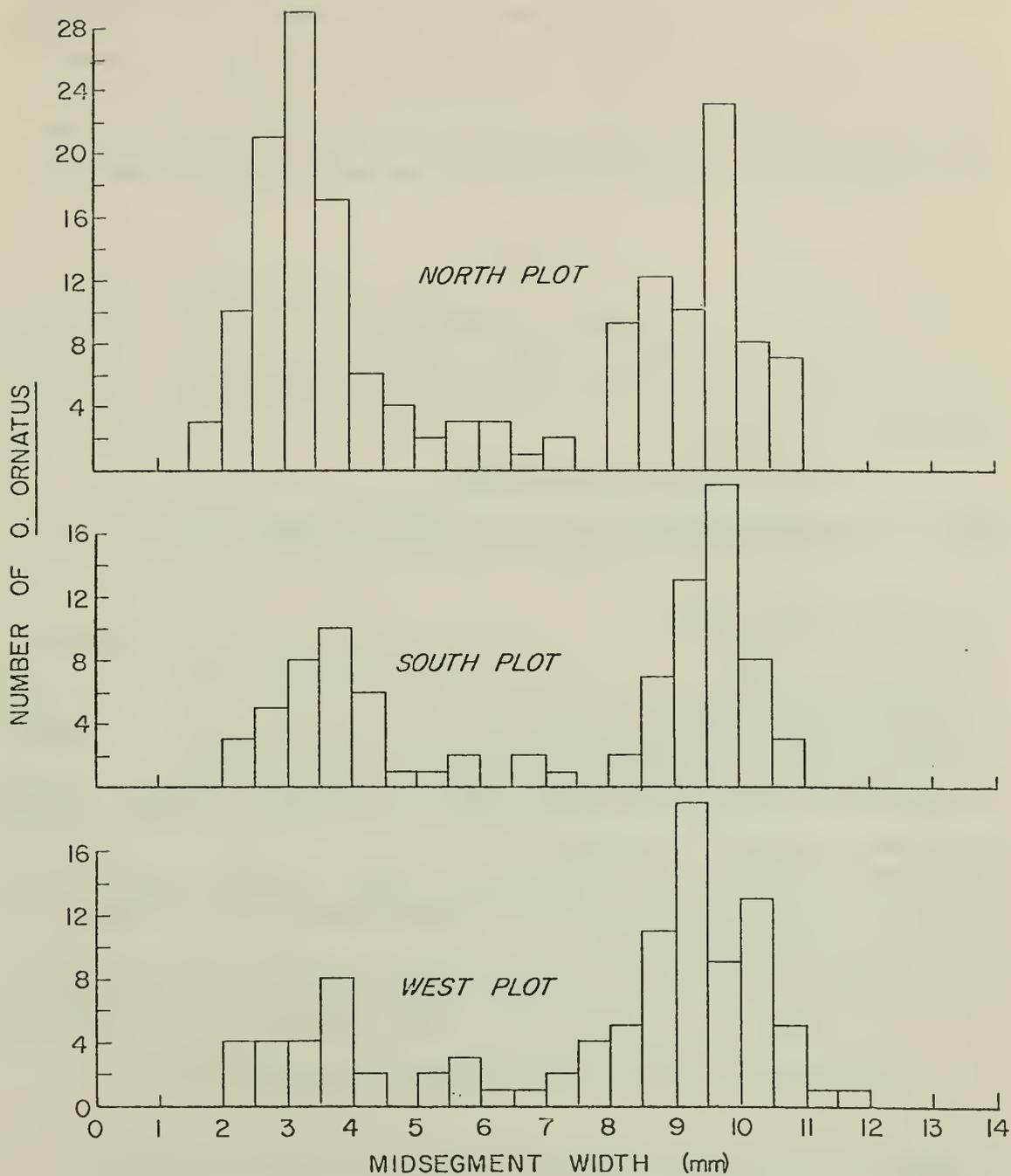


Fig. 1. Age (size) distribution expressed in terms of midsegment width of *O. ornatus* collected from three, 929 m<sup>2</sup> enclosure plots at Tornillo Flat between 23 May and 21 June 1973.

It can be concluded from the above and from associated information submitted to IBP that *O. ornatus* probably corresponds to forest millipedes in its relative importance as a plant nutrient-cycling agent. However, metabolically it is more efficient, which makes sense because it has a shorter feeding season in the desert.

Having extracted most of the desert millipedes from the Tornillo Flat enclosures, I would like to leave the enclosures up (they are lined by lawn-edging material) and to continue extracting over the years. The reason for this proposal is that if measurements of vegetative growth inside and outside the plots are simultaneously made for a number of years, it may be possible to directly relate millipede presence and absence to plant growth. In this way the real role of the desert millipede may be more clearly defined.

# # #

### STUDY OF THE MOTHS OF TEXAS

INVESTIGATOR: André Blanchard  
National Museum of Natural History  
American Museum of Natural History

SUMMARY OF PROGRESS: The following species occurring in Big Bend National Park are cited in papers published in 1973.

*Amplipterus donysa* (Druce)  
*Syntomeida melanthus* (Cramer)  
*Euxoa xasta* B. and Mc D.  
*Eriopyga mulina* Schaus  
*Iscadia daemonalis* Dyar  
*Herminodes stigmaphiles* (Dyar)  
*Givira redtenbacheri* (Hammerschmidt)  
*Heterocoma albistriga* B. and Mc D.

The following two species are described as new:

*Triozosneura dorsonotata* A. Blanchard  
*Glyphocystis viridivallis* A. Blanchard

There are still plenty of undiscovered and undescribed species in Texas, and particularly in Big Bend National Park.

# # #

### BASIC BIOLOGICAL RESEARCH ON THE LEPIDOPTERA OF BIG BEND NATIONAL PARK

INVESTIGATOR: Roy O. Kendall  
Florida Department of Agriculture and Consumer Services

SUMMARY OF PROGRESS: Only one visit was made to the park in 1973 (14-20 May). On this visit *Paratrytone melane vitellina* was taken, a new record for the park. Also, partial life history was worked out for *Apodemia chisosensis*, described from the park in 1964 from three specimens. Until now nothing has been known of its life history nor had any other specimen been taken. I have several larvae in diapause at

this time. If they survive until next year, sufficient data will be available to prepare a paper on its life history.

This project could be speeded up by spending 2 or 3 months in the park at a time. This could be done if accommodations could be made available.

# # #

#### MERCURY STUDY IN THE ROUGH RUN-TERLINGUA CREEK AND RIO GRANDE AREAS OF BIG BEND

INVESTIGATOR: James G. Houston  
Sul Ross State University

SUMMARY OF  
PROGRESS: The summary of the work to date and recommendation are included in a report submitted to the United States Department of the Interior, National Park Service, as required in the grand, Contract No CX 700030102.

# # #

#### ETHOLOGICAL STUDY OF *VERMIVORA CRISSALIS* IN THE CHISOS MOUNTAINS, TEXAS

INVESTIGATOR: Sharla M. Robinson  
Sul Ross State University

SUMMARY OF  
PROGRESS: In my 1973 study of the Colima Warbler (*Vermivora crissalis*) in the Chisos Mountains of Big Bend National Park, I was able to obtain data which will further the knowledge of the species' little-known life history. Territorial establishment and defense behavior were observed. Courtship behavior, previously unobserved, was recorded. Various other behavior of ecological significance was recorded.

I would like to give to the Naturalist Division, Big Bend National Park, recordings which were made of the Colima Warbler songs and also a copy of the manuscript which is now complete.

If I remain in Big Bend until the spring 1974 breeding season, I would like to do a "follow-up" study in an attempt to locate nests and to obtain better photographs of the Colima Warbler. If a study is feasible in 1974, I would again greatly appreciate the use of the Boot Spring Fire Patrol Cabin if arrangements could be made.

# # #

#### A PETROGRAPHIC STUDY OF THE ALKALINE IGNEOUS ROCKS OF BIG BEND NATIONAL PARK

INVESTIGATOR: Max F. Carman, Jr.  
University of Houston

SUMMARY OF FINDINGS have been summarized in previous reports; no new findings for  
PROGRESS: current year.

One visit was made to the park in the spring of 1973 in which a joint field excursion was held with previous investigators, Drs. Maryellen and Kenneth Cameron and Dr. Anthony Philpotts, University of Connecticut; the latter is a specialist in the study of alkaline rocks in the region of Montreal, Canada. We were examining various intrusives for evidence of liquid immiscibility in the original magma (a much disputed mechanism in the formation of igneous rocks). Everyone agreed that the evidence in Big Bend rocks is not conclusive.

A major manuscript entitled Petrology of the Rattlesnake Mountain Sill was submitted to the Geological Society of America in September 1973.

Max Carman is currently in leave in Europe: (a) In Portugal he is studying alkaline rocks that are similar to those of Big Bend. (b) At the Eidgenossische Technische Hochschule (Technical Institute) in Zurich, Switzerland, he is completing (spring 1974) the analysis and data-gathering of a study on alkali feldspar crystallization in the Rattlesnake Mountain Sill and the 4320 ft mountain near the NW corner of the park.

No new recommendations are made at this time, but it is planned to continue analysis of chemical data in the Big Bend area and to gather new chemical data on critical intrusives and extrusives. This will include detailed mapping of intrusives such as the intrusive complex of Dominguez Mountain.

Michael Daily, currently engaged in Ph.D. studies at CalTech, completed the dating of several of the intrusives in and near the park, using the K40-Argon method. The results will be presented in his Master's Thesis at the University of Houston.

# # #

ECOLOGY OF THE CARMEN MOUNTAINS WHITE-TAILED DEER  
BIBE-N-3a

INVESTIGATOR: Paul R. Krausman  
University of Idaho

SUMMARY OF This project is progressing as outlined in the original proposal.  
PROGRESS:

Data collection in progress:  
predator-prey relationships;  
dual-species interactions;  
behavior;  
taxonomy and distribution; and  
food habits

Data collection completed or terminated:  
habitat analysis; and  
telemetry.

REESTABLISHMENT OF HARLEQUIN QUAIL IN BIG BEND NATIONAL PARK  
BIBE-N-8

INVESTIGATOR: Ronald H. Wauer

OBJECTIVES: To reestablish Harlequin (Montezuma) Quail within the Chisos Mountains regime.

METHODS: Analysis of food sources was completed during previous years and followed by trapping and release of birds in habitat suitable for their subsistence. Population monitoring will determine success.

RESULTS AND DISCUSSION: Twenty-six birds were trapped near Nogales, Arizona, with the help of personnel of the Arizona Game and Fish Department. All of the birds survived the transporting from Arizona to Pine Canyon, Big Bend National Park, where they were released on 11 January 1973.

Two sightings of Harlequin Quail were reported since the release: (1) 20 were reported to be walking down the Pine Canyon road in mid-March, and (2) a park visitor observed one in the Pine Canyon about 10 April.

PLANS FOR 1974: Two visits to the release site are planned for 1974, during May and in late summer. The area will be surveyed on each visit, and food sources analyzed. The population will be monitored until such time as it is certain that the reestablishment was successful.

# # #

BEHAVIORAL ECOLOGY OF THE COLLARED PECCARY  
BIBE-N-9A

INVESTIGATOR: John A. Bissonette  
University of Michigan

SUMMARY OF PROGRESS: Progress has gone as planned. All vegetation work has been completed (see previous report for detailed description). The behavioral observations are being continued. I have one group marked and under intensive study since animals can be identified to individual recognition.

I have detailed, quantitative data on the breeding system not previously observed and published. My advisor believes that this work alone is most significant. My findings regarding the relationships between group size, range size, and range quality are consistent with the theory as proposed in my original proposal. In conjunction with a study of this sort, many subsidiary but important findings appear. They are too numerous to mention in a report such as this. The research, in its entirety, will be completed as a doctoral thesis and a copy of this will be sent to Big Bend National Park.

The future course of the research will proceed basically as planned and outlined in the original research proposal.

THE CHIROPTERA OF BIG BEND NATIONAL PARK, TEXAS  
BIBE-N-18

INVESTIGATOR: David A. Easterla  
Northwest Missouri State University

SUMMARY OF PROGRESS: During the summer of 1972, my dissertation Ecological aspects of the 18 species of Chiroptera at Big Bend National Park, Texas was completed. I am now in the process of publishing this manuscript.

Presently, nine publications have resulted directly from this research (for specifics see my 1971 and 1972 investigator's annual reports). Currently, I am writing three additional papers involving this project. Dr. Charles A. Triplehorn, Ohio State University, is presently writing a description of a new subgenus and species of Tenebrionid beetle that I discovered in Mt. Emory Cave while investigating the bat guano. During the summer of 1973, I secured considerable additional data on reproduction of the rare Spotted Bat.

My research on bats at Big Bend National Park in the future will focus primarily upon (1) recapturing banded bats and banding others; (2) continued ecological and life-history investigations of several of the rarer species, especially the threatened Spotted Bat.

Longevity and movement data can be obtained from banded bats only over an extended period of time. Some of my most significant data on longevity and movement undoubtedly will be obtained during future summers. Possibly this data will aid in determining why bat populations throughout the country have declined in recent years.

# # #

ANTS OF THE CHISOS MOUNTAINS, TEXAS  
BIBE-N-31

INVESTIGATOR: Arnold Van Pelt  
Greensboro College

SUMMARY OF PROGRESS: During the summers of 1969, 1970, 1971, and 1972, about 2000 ant colonies have been collected from the Chisos Mountains. Collections were made above the 4500 ft elevation line, restricting the study for the greater part of the woodlands.

Previous reports have described the probable distribution patterns of the species found in the Chisos woodlands and have defined ant habitats, both in terms of plant and ant aggregations.

Two papers published on phases of the field work completed so far have been deposited with the Chief Naturalist.

The park collection of ants now contains 188 specimens representing 25 genera and 63 species. All these specimens, except the few so labeled, were collected above 4500 ft elevation in the Chisos Mountains. Investigators interested in ecological data should contact me.

Although it was not contemplated in the original proposal, it now is indicated that field work should continue into the grassland areas surrounding the woodland, and then into the desert. If this program is approved, it should take an additional three to five summers.

I hope it will be possible to hole a V.I.P. appointment for research and to use a house in the park.

# # #

WINTER AND SPRING MOVEMENTS OF COYOTES (*CANIS LATRANS*) IN BIG BEND NATIONAL PARK  
BIBE-N-33

INVESTIGATORS: Douglas Stine )  
James F. Scudday ) Sul Ross State University

SUMMARY OF PROGRESS: Seven coyotes were trapped, fitted with radio transmitter collars, and released during January and February 1971. A total of 217 fixes was obtained between February and June 1971. However, only 44 individual fixes were obtained on two different individuals and as few as 10 fixes on one individual.

Most fixes were obtained in February when several continuous, 72-hour monitoring periods were conducted. The paucity of fixes during March, April, May, and June produced a sketchy pattern of movement at that time. However, such intermittent data showed the animal was staying well within the home-range areas established by continuous monitoring in February.

Home ranges were seldom more than 2.5 miles long by 1.5 miles wide (3.75 mile<sup>2</sup>), although coyote number 10/40 ranged over approximately 4.8 mile<sup>2</sup>, while number 7 mostly confined itself to about 2.5 mile<sup>2</sup>. Coyote number 10/95 was trapped at Dugout Wells and was monitored as he crossed the eastern end of the Chisos Mountains, across the Grapevine Hills, and left the park still traveling north. It is notable that this animal had only one functional eye; the other eye was blind due to some kind of physical damage to the eyeball. This was the only animal that was lost from the area by emigration.

Reducing the home ranges of each animal to a usable scale is still posing a problem in presentation. Interpretation of other kinds of data gathered during the course of study is yet to be completed.

# # #

MOUNTAIN LION STUDY  
BIBE-N-34B

INVESTIGATOR: Roy Mc Bride  
Sul Ross State University

SUMMARY OF PROGRESS: Purpose of study: (1) to determine extremities of Mountain Lion range and movements; (2) to relocate three lions or more in a new territory to see if they will remain; (3) to see if stock-killing lions can be removed to new areas where they will be out of contact with sheep and goat producers.

Results: Seven lions were fitted with radio transmitters and followed 1 year by aircraft. All but one were recovered and one has been sent to South Texas and is being followed by aircraft. Two more lions will be moved currently. A large amount of data has been gathered and will be used in writing a M.A. Thesis. When the work is completed, Big Bend National Park will be given a complete report along with a copy of the thesis.

# BIGHORN CANYON NATIONAL RECREATION AREA

## CREEL CENSUS AND GROWTH AND MOVEMENT STUDY OF TROUT IN THE BIGHORN RIVER

INVESTIGATOR: Harold R. Stevenson  
Montana State University

SUMMARY OF PROGRESS: Field data collected June 1972 to September 1972 and April 1973 to September 1973 are being summarized and will be compiled in thesis form by April 1974.

The purpose of this study was to evaluate the fishery of the Bighorn River below Yellowtail Dam. The primary objectives were to obtain estimates of total fishing pressure, catch rate, and yield of game fish for the upper 14 miles of the river. Additional information was obtained on the success of stocking hatchery fish and natural reproduction and growth rate.

Three study sections were chosen based upon fisherman access along with qualitative and physical characteristics of the fishery. The after bay is section A, section B includes the first 2 miles below the after-bay dam, and section C is that portion of the river beginning 2 miles below the after-bay dam and continuing approximately 10 miles downstream to the Montana Fish and Game Bighorn Fishing Access.

The after bay and river census data will be analyzed as two separate fisheries and the two compared. Statistical analysis of variables counted will be made (statistical model) in an attempt to find one or two variables that can be used to project fishing pressure without actually observing all the fishermen.

# # #

## LIMNOLOGY OF YELLOWTAIL RESERVOIR AND THE BIGHORN RIVER

INVESTIGATORS: John C. Wright )  
Raymond A. Soltero ) Montana State University  
Abraham Horpestad )

SUMMARY OF PROGRESS: Only the results of the zooplankton have not been compiled. These will appear as a Ph.D. Thesis of Abraham Horpestad.

BISCAYNE NATIONAL MONUMENT

CORAL REEF ECOLOGY  
BISC-N-3

INVESTIGATORS: Gary E. Davis )  
L. Lee Purkerson) National Park Service

SUMMARY OF Objectives, methods, and results same as last year. Plans for next year  
PROGRESS: dependent on funding in FY 75.

# # #

REEF FISH ECOLOGY OF POPULATION DYNAMICS  
BISC-N-4

INVESTIGATOR: Gary E. Davis  
National Park Service

SUMMARY OF Same as last year, but add to "Plans for next year." Continuation of this  
PROGRESS: project depends on FY 75 funding.

# # #

AN ECOLOGICAL STUDY OF OLD RHODES KEY LAGOON  
BISC-N-8

INVESTIGATOR: Robert Holm  
Northwestern University

SUMMARY OF First field period completed March-August 1973. Sixty epibenthic,  
PROGRESS: 144 plankton samples taken. In addition, 50 fish stomachs, and 5 months'  
abiotic (temp. salinity, tides, etc.) data taken. Data are now being  
analyzed. Fifteen epibenthic samples have been sorted. Abiotic data are being analyzed.  
Remainder of data have yet to be examined. A graduate committee meeting at the end of  
January 1974 will determine the course of action to be taken for the remainder of the  
study. Plan is for one more field period from (tentatively) March-August 1974.

# BLACK CANYON OF THE GUNNISON AND COLORADO NATIONAL MONUMENTS

## COMMON DEER MOUSE, *PEROMYSCUS MANICULATUS*

INVESTIGATOR: Lee R. G. Snyder  
Stanford University  
Rocky Mountain Biological Laboratory

SUMMARY OF PROGRESS: I wish to investigate genetic differentiation between natural population of deer mice living on the north and south rims of Black Canyon. That project is part of a larger survey of the population genetics of deer mice throughout western Colorado. I was all set to begin collecting in July 1973, when I was informed that the original funding for the project had been canceled. Hence I did no collecting of mice within the monument. However, I have been assured of funding for the coming summer and hope to commence the project at that time.

## BLUE RIDGE PARKWAY

LIMITED COLLECTION OF THE DOMINANT VASCULAR PLANTS AND BRYOPHYTES FOR IDENTIFICATION AND FOR USE IN THE DISPLAYS AND HERBARIUM IN THE BIOLOGY DEPARTMENT OF MARS HILL COLLEGE

INVESTIGATOR: Joseph R. Taylor  
Mars Hill College

SUMMARY OF PROGRESS: We need to resume the collection and study this next spring and summer. I think the direction we are following is good. If we have release time, more time could be allotted with perhaps a special grant to study a specific group of plants. Much of the time of the applicant is spent in instruction.

The Blue Ridge Parkway is a wonderful experience with the alpine flora, different ecosystems, and different elevations. We used the services of the Blue Ridge Parkway last summer with our Field Botany class. We did not do any collecting last summer, however. The flowering plants were a challenge for the class. We wish to resume some collecting and identification this summer of 1974. We have no publication during this past year related to research of the project.

We appreciated the opportunities afforded by the staff of the National Park Service through granting Collection Permits and through service as resource personnel. It is our hope that this type of relationship may be continued.

# # #

## STUDIES OF *CRYPTOCERCUS PUNCTULATUS* HIND-GUT PROTOZOA

INVESTIGATOR: Hope Ritter, Jr.  
University of Georgia

SUMMARY OF PROGRESS: *Cryptocercus* was collected on three occasions. Collection sites most frequently used were the areas of Soco Bald, off the trail top area at Richland Balsam and Mount Pisgah. Sample collections were made at mile posts between Soco and Pisgah at 5-mile intervals if forest cover and parking factors were suitable.

Collected individuals have been applied to two studies to date: one of these involves a joint investigation with Dr. Donna Kubai from the laboratory of Dr. Hans Ris at the University of Wisconsin, Madison. In this study hind-gut protozoa inoculated into my anaerobic culture medium undergo cell reproduction. A species of protozoa named *Barbulanympa* is removed from culture at various times when various stages of meiosis are expected. Dr. Kubai prepares and preserves such individuals for electron microscope studies with Wisconsin's million volt electron microscope this winter. Being living fossils in a sense, we expect to find a transitional stage in the manner in which cells have undergone meiotic evolution. The other study of all hind-gut protozoa indicates the presence of one or two protozoan species in *Cryptocercus* collected along Blue Ridge (especially at altitudes in excess of 5800 ft) not found in *Cryptocercus* collected at lower altitudes (down to 3000 ft) in Georgia and at Mt. Lake, Virginia Biological Station. The significance of this observation is in no way clear as yet.

To the extent that my winter teaching program will permit, I intend to pursue studies on Blue Ridge collected material as well as on material collected from the National Forest in the vicinity of Camp Tumbling Waters 20 miles west of Clayton, Ga. I will request permit renewal for the 1974 season and studies will be continued until present questions on fundamental living process have been answered.

# # #

## ECOLOGICAL-FLORISTICS OF THE CENTRAL VIRGINIA BLUE RIDGE MOUNTAINS AND STUDY OF UNUSUAL VASCULAR EPIPHYTES

INVESTIGATOR: Gwynn W. Ramsey  
Lynchburg College

SUMMARY OF PROGRESS: The ecological-floristics of the central Virginia Blue Ridge Mountains is a project which I have worked on in conjunction with Dr. Ruskin S. Freer. This past year only a few collections were made. He will include pertinent information in his report. This is a project which has continued through the years and new and interesting plant finds and relationships are being brought to light each year.

Along with my report in 1972, I submitted an article published on our finds of unusual vascular epiphytes along the parkway in central Virginia. This year we have found several more cases of vascular epiphytism. This winter my students and I will be searching for cases of unusual green epiphytes along the parkway. There is reason to believe we can find *Rhododendron* growing epiphytically up in certain trees much as is found in the Smokies. I have one student who will be working on a project during the spring semester for senior research credit concerned with this interesting phenomenon.

We do have a number of vascular plants (duplicate specimens) which will be placed in the Peaks-Of-Otter Herbarium in the near future.

THE ECOLOGY OF POPULATIONS OF THE SALAMANDER *DESMOGNATHUS OCHROPHAEUS*

INVESTIGATOR: Stephen G. Tilley  
Smith College

SUMMARY OF PROGRESS: During the summer of 1973, photomarking studies were continued on the two rock faces of Black Mountain Gap. About 100 individuals of *Desmognathus ochrophaeus* were collected near the pinnacle for genetic studies. A manuscript reporting on our work on rockface populations along the parkway has been prepared, and will appear in Ecology in 1974. Reprints will be provided when they become available.

The photomarking work has now been terminated but we plan to work in the southern Appalachians during the coming summer. Our work will probably focus on ecological interactions between *D. ochrophaeus* and *D. fuscus* and will involve collecting along the Great Balsam Mountains section of the parkway.

# # #

ON THE VEGETATION IN A BURNED AREA IN THE PISGAH NATIONAL FOREST,  
HAYWOOD COUNTY, NORTH CAROLINA

INVESTIGATOR: William T. Penfound  
Warren Wilson College

SUMMARY OF PROGRESS: *Introduction:* Along the Blue Ridge Parkway, between mileposts 416 and 424, is an area of 25,000 acres largely devoid of coniferous trees. This region has been designated as Graveyard Fields because a tremendous wind had blown down many trees of the spruce forest covering the area. This blow-down produced mounds and accompanying depressions at the root end of the downed trees. On Thanksgiving Eve 1925, a great fire destroyed over 25,000 acres of high grade timber in the region (Lord 1969). A subsequent fire, in 1942, burned a considerable area in Graveyard Fields (Rogers 1973).

Our study was initiated on 1 June 1973 and was discontinued on 30 September 1973. Weekend visits were made every 2 weeks throughout this period. Included in the investigation were: descriptions of plant communities, phenology of plants, rate of growth of trees, depth of peat, and location of seedlings of red spruce and Fraser fir.

*Environment:* According to Whittaker (1956), high elevations in the Great Smoky Mountains average 10 to 15° cooler than at the base of the mountains during the growing season. Annual precipitation values range from 50 to 60 inches in the lower valleys to more than 80 inches at high elevations (Whittaker 1956). High elevations in the Great Smokies and the Blue Ridge Mountains are characterized by haze, drifting clouds, considerable fog, and summer thunderstorms. It seems probable that the climate of the Graveyard Field area is similar to that of the "high country" in the Great Smokies since vegetation types are similar. The soils are also similar, with 4-12 inches of peat underlain by a gray podzolic surface horizon.

*Vegetation types:* The spruce-fir forest is dominated by *Picea rubens*<sup>1</sup> (red spruce) and *Abies fraseri* (Fraser fir). Occasional specimens of *Betula lutea* (yellow birch), *Rhododendron catawbiense* (purple laurel), and *Sorbus americana* (mountain ash) are

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<sup>1</sup>All names according to Radford et al. (1968)

encountered, especially in openings where trees have been cut or blown down. The only species of importance in the ground cover of an undisturbed forest is *Oxalis acetosella* (wood sorrel). However, with disturbance a number of species common in the yellow birch forest may become established. The substrate consists of 5-9 inches of peat resting on a gray, sandy, mineral soil.

**Yellow birch forest:** The closely related, but deciduous, forest of yellow birch includes several more woody species and many deciduous herbs. Although the dominant is *Betula lutea*, there are many specimens of *Rhododendron catawbiense* and *Sorbus americana*. Unlike the spruce-fir forest, there is a continuous ground cover, primarily of *Aster acuminatus*, *Aster divaricatus*, *Athyrium asplenioides*, (lady fern), and *Eupatorium rugosum* (thoroughwort).

**Laurel shrubland:** The laurel shrubland is conspicuous on north-facing slopes. Often called laurel slicks or heath balds, they are composed primarily of evergreen shrubs from 4 to 12 ft high. The substrate consists of peat from 6 to 10 inches deep underlain by a gray, sandy surface horizon. Shrubs, in order of importance, include *Rhododendron catawbiense*, *Kalmia latifolia* (mountain laurel), *Pieris floribunda* (fetter-bush), and *Vaccinium constablei* (highbush blueberry). In addition, there are numerous specimens of deciduous, woody species from the deciduous thicket community. Important in the ground cover are *Dennstaedtia punctilobula* (hay-scented fern), *Galax aphylla* (galax), and *Lycopodium obscurum* (groundpine).

**Perennial forbland:** Along the Art Loeb Trail, at elevations up to 6000 ft is an area with considerable peat (3 to 6 inches) but almost no ericaceous plants. Instead it is occupied by *Rubus canadensis* (blackberry), *Angelica triquinata* (angelica), and *Athyrium asplenioides*. Overgrowing and destroying some of the current growth of these species is *Cuscuta rostrata* (dodder). Although a total of 9 woody species and 32 herbs were encountered, the above species accounted for most of the biomass produced during the current summer.

**Grassy ridges:** Above the perennial forbland, on the Art Loeb Trail, are exposed ridges populated primarily by agrostoid species. These communities have been designated as grass balds and occur between 4700 and 6100 ft (Mark 1959). He lists 32 natural grass balds and 453 species of plants. Our limited study suggests *Athyrium asplenioides*, *Danthonia compressa* (oat grass), *Deschampsia caespitosa* (hair grass), and *Phleum pratense* (timothy) as the predominant herbs. Many woody species, including *Picea rubens*, are scattered throughout the grassy sward.

**Deciduous thicket:** In the area near the East Fork Overlook on the Blue Ridge Parkway is a dwarf deciduous forest with numerous openings. In this deciduous thicket the predominant woody species are *Amelanchier arborea* (serviceberry), *Ilex ambigua* (mountain Holly), and *Prunus pennsylvanica* (fire cherry). The absence of evergreen ericads is in direct contrast to the composition of the laurel shrubland on the opposite, north-facing slope. It seems probable that the absence of the ericads is due to the destruction of the peat by the original conflagration. At present, the depth of the peat ranges from 1 to 3 inches in the deciduous thicket as against 6 to 10 inches in the laurel (ericad) shrubland. It seems possible, also, that regeneration of the ericads may be meager because the deciduous thicket is located on a south-facing slope.

**Deciduous savanna:** In a relatively flat portion of the deciduous thicket much used by campers, there is a relatively open area which we have indicated as deciduous savanna. Small trees of the deciduous savanna are scattered through a grassy sward of *Danthonia compressa* and *Deschampsia flexuosa*. In addition, there are many scattered specimens of *Vaccinium constablei*.

**Road cuts:** Many road cuts were produced when the Blue Ridge Parkway was constructed. These raw, roadside cuts were planted with several cultivars which have been eliminated gradually by native species. At present there are abundant seedlings of *Rhododendron catawbiense* on the mineral soil of these road cuts. Another predominant woody species is *Diervilla sessilifolia* (bush honeysuckle). Since there are many herbaceous species, it is difficult to designate the most important ones. However, *Houstonia purpurea* (bluets) and *Lycopodium clavatum* (running clubmoss) seem to be present in all of the

examples investigated. The parking areas at the various overlooks contain the greatest number of herbaceous species. Since these species are cultivars, they are not included in this discussion.

*Boggy areas:* Throughout the Graveyard Fields there are many boggy areas. These are especially abundant in the laurel shrubland, the deciduous thicket, and the deciduous savanna. Sphagnum moss and peat, from 8 to 12 inches deep, are characteristic of the "bogs" studied. The predominant species, in the course of our investigation, were *Carex erineta* (nodding sedge), *Carex intumescens*, and *Glyceria striata* (manna grass).

*Regeneration of the spruce-fir forest:* In the Blue Ridge Parkway guide it is indicated that "Trees planted by the Forest Service have grown back very slowly for the soil after the fire is pitifully thin . . . Nature's way of building back the humus has begun . . . But a hundred years may be needed to restore the spongy soil required by these spruce-fir forests so rare in the Southern Highlands . . ." (Lord 1969). In our study there are three observations which may be relevant: (1) seedlings of red spruce and Fraser fir occur abundantly on mineral soil along spruce-fir forest margins; (2) there are very few seedlings of spruce and fir in the laurel shrubland, although the peat ranges from 6 to 10 inches in depth; and (3) no spruce or fir seedlings have been found under or around isolated trees. It is well known that species of spruce and fir germinate best on mineral soil. Egler (1973) says "So do most tree seedlings, as any horticulturist knows . . ." It appears, therefore, that reproduction of spruce and fir does not require peat. The lack of reproduction in the laurel shrubland could be due to the absence of seed, to the competition of the evergreen shrubs, or both. The growth of seedlings and saplings in the laurel shrubland is very slow (2 to 3 in/yr) a possible factor in their ecesis. The absence of seedlings around isolated trees may be due to the consumption of the seeds of spruce and fir by birds and rodents, except in unusual years of heavy seed production. The lack of reproduction of spruce and fir is probably due to several factors, of which availability of seed may be one of the most important.

References:

- Egler, F. E. 1973. Wilderness east? Yes, incontestably. *Ecology* 54(4):721-722.  
Lord, W. G. 1969. The Blue Ridge Parkway Guide: Asheville to Great Smokies. The Stephens Press, Asheville, N.C.  
Mark, A. F. 1959. The flora of the grass balds and fields of the South Appalachian Mountains. *Castanea* 24:1-21.  
Rogers, L. K. 1973. Fire in the Graveyard Fields (Personal correspondence).  
Radford, A. E., H. E. Ahles, and C. R. Bell. 1968. Manual of the vascular plants of the Carolinas. Univ. of N.C. Press, Chapel Hill, N.C.  
Whittaker, R. H. 1956. Vegetation of the Great Smoky Mountains. *Ecol. Monogr.* 26(1):1-80.

# # #

UNDERGRADUATE BIOLOGY CLASS (UPPER CLASS LEVEL) FIELD STUDIES  
BLRI-N-22

INVESTIGATORS: Dennis L. Stockdale)  
William T. Penfound) Warren Wilson College  
Willis A. Egler )

SUMMARY OF PROGRESS: We take our upper-students in courses such as biotoxonomy and bioecology, out to the surrounding areas for on-site studies and minimal collecting (in protected areas). All specimens collected are available for public or institutional study or use in our herbarium.

## GEOLOGY OF THE SKYLAND - DUNSMORE QUADRANGLES

INVESTIGATOR: Abdallah E. Dabbagh  
University of North Carolina

SUMMARY OF PROGRESS: Structural data were collected as well as samples. Analysis of these samples is progressing. Drafting of map and writing of text will start June 1974.

# # #

## FLORISTICS OF CENTRAL VIRGINIA BLUE RIDGE

INVESTIGATOR: Ruskin S. Freer  
Lynchburg College

SUMMARY OF PROGRESS: Since March, I have been occupied with a revision of my 1939 paper, Birds of Lynchburg, Virginia and Vicinity. Manuscript has been completed and will be published by Lynchburg College. I took only one plant-collection trip the past season, but plan to resume in the spring of 1974.

# # #

## SYSTEMATICS OF PLETHODONTID SALAMANDERS EVOLUTIONARY BIOLOGY OF SALAMANDERS OF THE GENUS *PLETHODON*

INVESTIGATOR: Richard Highton  
University of Maryland

SUMMARY OF PROGRESS: We have a number of projects underway. They include all sorts of studies relating to the evolutionary biology of plethodontid salamanders, primarily those of the genus *Plethodon*. They include studies on the comparative life histories of species and geographic variation of life histories within species; analyses of geographic variation in color characters and morphological features; inter- and intraspecific variation in blood proteins; ecological interactions of closely related species; population genetics; taxonomy; intergradation and hybridization; and geographic distribution of these salamanders.

We study the above features of the biology of these salamanders throughout eastern North America. Our collections along the Blue Ridge Parkway are only a very small part of our research effort, but an important one since the Blue Ridge Mountains are inhabited by more species of *Plethodon* than anywhere else, and many of these salamanders are restricted to higher altitudes accessible only by roads like the parkway that pass along the crests of the highest mountains.

Specimens of salamanders of the genus *Plethodon* collected along the Blue Ridge Parkway in 1973:

Field #	Species	Date	#	Locality
73-112	<i>P. jordani</i>	22 May	16	BRP mile 422.8
73-110	<i>P. nettingi</i>	24 May	68	BRP mile 80.9
73-110	<i>P. glutinosus</i>	24 May	10	BRP mile 80.9
73-172	<i>P. jordani</i>	28 July	17	BRP mile 451.2
73-173	<i>P. jordani</i>	28 July	16	BRP mile 441.5
73-173	<i>P. glutinosus</i>	28 July	2	BRP mile 441.5
73-175	<i>P. jordani</i>	29 July	80	Cutthroat Gap, jct. of BRP & NC Rt 151
73-187	<i>P. jordani</i>	19 Aug.	28	BRP mile 451.2
73-188	<i>P. jordani</i>	19 Aug.	28	BRP mile 441.5
73-188	<i>P. glutinosus</i>	19 Aug.	2	BRP mile 441.5
73-221	<i>P. cinereus</i>	14 Oct.	23	BRP mile 103.7
73-221	<i>P. glutinosus</i>	14 Oct.	9	BRP mile 103.7
73-222	<i>P. cinereus</i>	14 Oct.	7	BRP mile 89.1

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306 Total

NOTE: Many of the animals listed above were not collected on national park territory since we sometimes collect beyond the narrow parkway limits.

# # #

#### GYPSY MOTH SURVEY - TRAPPING

INVESTIGATOR: William D. Jones  
U.S. Department of Agridulture

SUMMARY OF Gypsy moth traps, baited with the sex attractant disparlure, were placed  
PROGRESS: at irregular intervals along the Blue Ridge Parkway from MP-0 to the  
Virginia-North Carolina state line and in adjacent camping areas. No  
moths were recovered on Department of Interior property.

# # #

#### A BIOSYSTEMATIC STUDY OF THE *CALYSTEGIA SPITHAMAEA-CATESBEIANA* COMPLEX

INVESTIGATOR: Patrick B. Mikesell  
Pennsylvania State University

SUMMARY OF This project is now in its final stages and the results are being  
PROGRESS: examined and conclusions drawn. Writing is underway and it is hoped  
that the dissertation will be completed by March 1974.

It was not necessary for additional field work to be conducted during the 1973 growing season and therefore no collections were made on the Blue Ridge Parkway.

COLLECT TWIGS, BUDS (WINTER), AND LEAVES (SUMMER)

INVESTIGATOR: Frank H. Miller

SUMMARY OF  
PROGRESS: Collecting in 1973 was limited to a few special areas for scarce or rare plants. *Pyrus melanocarpa* had been found at Pisgah Camp Ground, and an intensive search located the other two species, *Pyrus arbutifolia* and *P. floribunda*. The former was found at the Pisgah Camp Ground and the latter at Frying Pan Gap.

A rare *Vaccinium* was found in the Pisgah Camp Ground, the species *V. atrococcum* (Gray) Heller. This is the Black Highbush Blueberry, supposedly growing in bogs and swamps at medium and lower elevations.

Most of the time during the year was spent on the text, keys, making photo prints, and preparing the twig and bud drawings.

# # #

ANALYSIS OF THE LATE-BLOOMING FORM OF *RHODODENDRON CALENDULACEUM*

INVESTIGATOR: Frank F. Willingham  
Wake Forest University

SUMMARY OF  
PROGRESS: This project, as described in previous reports, is now complete. Preparation of a manuscript for publication in a scientific journal is underway and should be in print within the next year.

Briefly, the results of this study indicate that the flame azalea *R. calendulaceum* is a highly variable species which occurs in a variety of colors and growth habits. Hybridization between it and other azalea species is now thought to occur less often than has been reported. *Rhododendron bakeri*, a north Georgia species of azalea, is now not thought to be involved in the origin of the so-called late-blooming form of *R. calendulaceum* and, indeed, *R. bakeri* does not seem to be a separate species. Morphological data suggest that *R. bakeri* is a diploid form of *R. calendulaceum* and there is evidence to suggest that the tetraploid *R. calendulaceum* arose from it by the process of autotetraploidy.

No plant material was collected along the Blue Ridge Parkway in 1973.

Some follow-up work seems appropriate in the future, therefore a collecting permit is being applied for.

# # #

GEOLOGY OF THE MARION AND LITTLE SWITZERLAND QUADRANGLES, NORTH CAROLINA

INVESTIGATOR: James Robert Butler  
University of North Carolina

SUMMARY OF  
PROGRESS: Geologic mapping and laboratory studies are in progress.

SIGNIFICANT FINDINGS: Results are important additions to regional geology.

RECOMMENDATIONS: Proceed as planned.

# # #

#### GEOLOGICAL INVESTIGATION OF THE NORTHWEST FLANK OF THE BLUE RIDGE

INVESTIGATOR: Edgar Winston Spencer  
Washington & Lee University

SUMMARY OF I am involved in a long-term investigation of the structural geology  
PROGRESS: of the Blue Ridge and its relationship to the rock units of the valley of  
Virginia. This work does not consist of a single project, but is part  
of a long-term research interest.

During the past year I have worked primarily in the Glasgow Quadrangle, with only a few days on the parkway in the Buena Vista and Snowden quadrangles. Geological mapping is nearly complete in the Glasgow Quadrangle and a report is being submitted to the Virginia Division of Mineral Resources for publication.

I expect to carry out an investigation into the geologic hazards and other environmental problems in this area in the years ahead.

Rocks were examined within the park but none were collected during this year.

# # #

#### HERBARIUM COLLECTION

INVESTIGATOR: Charles Morlang, Jr.  
Hollins College

SUMMARY OF I made only one field trip to Rock Castle Gorge and made no significant  
PROGRESS: collections. I was, however, very disturbed by the road "improvements."  
In the future, collectors should be notified that such damage is to be  
done so that rare species can be collected or transplanted.

# # #

#### VASCULAR FLORA OF THE CAROLINAS

INVESTIGATOR: J. Dan Pittillo  
Western Carolina University

SUMMARY OF Redbank Branch Cove (just north of the first overlook--not the  
PROGRESS: information area--and 1.4 miles south of Balsam Gap) was collected and  
I would recommend this be included as an important "natural area" based  
upon the herbaceous community there. The rarer plant Nodding mandarin [*Disporum*

*maculatum* (Buckley) Britton, Liliaceae] is reported by Radford, Ahles, and Bell (1968) for only two counties in the Carolinas. A second species, also rare, Golden saxifrage (*Chrysoplenium americanum* Schweinitz, Saxifragaceae), is scattered along the rocky stream bed. Both these plants represent records for Haywood County.

Additionally, *Aconitum ucinatum* L. (Ranunculaceae) and *Sanicula trifoliata* Bicknell were collected in the same cove. The *Aconitum* was rare at the lower end; perhaps more populous upstream, though I have not checked this possibility out.

Reference:

Radford, A. E., H. E. Ahles, and C. R. Bell. 1968. Manual of the vascular flora of the Carolinas. Univ. of North Carolina Press, Chapel Hill.

# # #

PRACTICUM IN TRAINING OF INTERPRETIVE NATURALISTS  
USING THE BLUE RIDGE PARKWAY AS A LEARNING LABORATORY

INVESTIGATORS: I. W. Carpenter) Mars Hill College and  
Homer H. Hurley) Appalachian State University  
J. E. Jolly )

SUMMARY OF It is hoped that the Biology Department of Appalachian State University  
PROGRESS: can develop a program leading to a degree as an interpretive naturalist.  
This program would include the use of interns on the Blue Ridge  
Parkway each summer and perhaps at other times as well. The idea is in a formative  
stage, but Dr. Jolly from Mars Hill and personnel of the Blue Ridge Parkway have  
indicated interest in the project. The go ahead has not been granted by the Trustees of  
Appalachian State University or the University of North Carolina. As soon as approval  
is obtained, plans will be made with the Blue Ridge Parkway.

# # #

FLORA OF SIMS POND AREA

INVESTIGATORS: Mike Livengood ) Appalachian State University  
I. W. Carpenter)

SUMMARY OF A floristic study was made of Sims Pond Area resulting in a catalogue  
PROGRESS: of the vascular flora.

PHYTOECOLOGY OF BOONE FORK SPHAGNUM BOG

INVESTIGATORS: Terry A. Moore )  
J. Frank Randall) Appalachian State University

SUMMARY OF A phytoecological study was made and permanent research plots  
PROGRESS: established.

# # #

STUDIES ON TERRESTRIAL INVERTEBRATES OF NORTH CAROLINA

INVESTIGATOR: Rowland M. Shelley  
North Carolina State Museum

SUMMARY OF The project involves the collection of several groups of terrestrial  
PROGRESS: invertebrates in North Carolina to determine species present and their  
distribution within the state. Primary emphasis has been placed on  
the millipedes, with the ultimate goal being a detailed publication on the millipedes  
of North Carolina. This requires collecting across the state, but mountains and western  
piedmont will receive the most attention due to the preponderance of millipedes in these  
areas. The Blue Ridge Parkway and associated areas offer excellent millipede habitat  
which should be investigated in the course of a state-wide study.

I have not restricted myself to a time schedule. It will take years before this  
project can be completed, but considering the paucity of knowledge of millipedes and the  
other groups, not only in North Carolina but throughout the world, it is certainly a  
worthwhile goal. At present, the percentage completed is nil, but I am currently  
preparing a paper on the millipedes of William B. Umstead Park outside of Raleigh. There  
are a number of literature records for North Carolina, and others have collected in the  
state. With these plus my own efforts, the total picture will gradually become clear.

For the future, it would be advisable to continue collecting across the state in a  
systematic way--zeroing in on areas that have received less attention, plotting the  
results on maps, and using these to guide further work. I eventually plan to go into all  
areas of the state. There will be times when I collect around the parkway intensely  
and there will be times when I collect there very little, concentrating instead on other  
areas. I hope this won't affect the status of my permit.

I hope this provides some description of my work. Below is a list of those few  
specimens I have collected along the parkway since 29 August, when my permit was issued.

9 September 1973

Julian Price Memorial Park vicinity

Isopod - *Ligidium longicaudatum*  
Millipede - *Nannaria* sp.

10 September 1973

Doughton Park Vicinity

Millipedes - *Cambala annulata*  
*Abacion magnum*  
*Cleidogona major*  
*Polyzoniium* sp.

APHIDIDAE OF NORTH AMERICA

INVESTIGATOR: Clyde F. Smith  
North Carolina State University

SUMMARY OF PROGRESS: The following aphids were collected from "moss" along the Blue Ridge Parkway during 1973: *Decorosiphon corynothrix* C.B.; *Muscaphis stammeri* C.B.; *Pseudacaudella rubida* C.B.; *Jacksonia papillata* Theo.; *Myzodium modestum* Hottes.

The first three species are new records for North America. All five species are new records for North Carolina.

*Pseudacaudella rubida* was parasitized by *Monoctonus caricis* (Haliday). This is a new record for North America and the first definitely known record of the host for *M. caricis* even though *caricis* was described 150 years ago.

# # #

A MACROLICHEN FLORA OF THE HIGH-MOUNTAIN AREAS  
ABOVE 5,500 FEET IN THE SOUTHERN APPALACHIANS  
BLRI-N-22

INVESTIGATOR: Jonathan P. Dey  
Duke University

SUMMARY OF PROGRESS: Field work is 95% completed. All specimens collected so far have been pressed, packeted, and labeled. Approximately 75% of these have been identified to species. Thin-layer chromatographic analyses have been performed on over 2000 specimens to determine their natural product chemistry and the naturally occurring chemical variation within each species. Excellent progress is being made on this phase of my project.

In addition to my own field collections, I am presently studying specimens deposited in both the University of Tennessee Herbarium and the U.S. National Herbarium at the Smithsonian Institution which were collected from my study area. The Smithsonian collection include many valuable duplicate packets of Prof. Gunnar Degelius and his 1939-40 study of the lichens of the Great Smoky Mountains National Park.

Two new species of *Parmeliae* have been discovered and will be described in a paper this coming year. A paper in press, The Bryologist, Winter 1973, discusses and reports for the first time two lichens new to the southern Appalachians--*Parmelia sinuosa* and *Parmelia incurva*.

I would like to request a renewal of my collecting permit for 1974.

## SPECIES LIST

All lichen specimens collected in this study are presently located in the Duke Herbarium. Identification of these specimens is continuing at the present time. The following is a list of species identified at this time from the high-mountain areas as a whole:

<i>Alectoria americana</i>	<i>Cladonia strepsilis</i>	<i>Parmelia catawbiensis</i>
<i>A. bicolor</i>	<i>C. uncialis</i>	<i>P. conspersa</i>
<i>A. nadvornikiana</i>	<i>C. verticillata</i>	<i>P. crinita</i>
<i>A. nidulifera</i>	<i>C. vulcanica</i>	<i>P. croceopustulata</i>
<i>A. fallacina</i>		<i>P. cumberlandia</i>
	<i>Coccocarpia cronia</i>	<i>P. densirhizinata</i>
<i>Anaptychia palmulata</i>		<i>P. dissecta</i>
	<i>Collema flaccidum</i>	<i>P. flaventior</i>
<i>Anzia americana</i>	<i>C. furfuraceum</i>	<i>P. galbina</i>
<i>A. colpodes</i>	<i>C. migrescens</i>	<i>P. gondylophora</i>
	<i>C. subfurvum</i>	<i>P. halei</i>
<i>Baeomyces fungoides</i>		<i>P. horrescens</i>
( <i>B. roseus</i> )	<i>Erioderma mollissimum</i>	<i>P. imbricatula</i>
<i>B. rufus</i>		<i>P. incurva</i>
	<i>Gymmoderma lineare</i>	<i>P. laevigata</i>
<i>Cetraria aurescens</i>		<i>P. margaritata</i>
<i>C. ciliaris</i>	<i>Heterodermia cf casarettiana</i>	<i>P. mellissii</i>
<i>C. halei</i>	<i>H. dendritica</i>	<i>P. nakanishii</i>
<i>C. hepatizon</i>	<i>H. leucomela</i>	<i>P. omphalodes</i>
<i>C. islandica</i>	<i>H. obscurata</i>	<i>P. perlata</i>
<i>C. oakesiana</i>	<i>H. squamulosa</i>	<i>P. plittii</i>
<i>C. orbata</i>	<i>H. tremulans</i>	<i>P. rachista</i>
		<i>P. reddena</i>
<i>Cetrelia cetrarioides</i>	<i>Hypogymnia krogii</i>	<i>P. reticulata</i>
<i>C. chicitae</i>	( <i>H. enteromorpha</i> )	<i>P. revoluta</i>
<i>C. olivetorum</i>	<i>H. physodes</i>	<i>P. rockii</i>
	<i>H. tubulosa</i>	<i>P. rudecta</i>
<i>Cladina arbuscula</i>	<i>H. vittata</i>	<i>P. saxatilis</i>
<i>C. rangiferina</i>		<i>P. sinuosa</i>
<i>C. subtenuis</i>	<i>Lasallia papulosa</i>	<i>P. spumosa</i>
	<i>L. pennsylvanica</i>	<i>P. squarrosa</i>
<i>Cladonia apodocarpa</i>		<i>P. stygia</i>
<i>C. bacillaris</i>	<i>Leptogium americanum</i>	<i>P. stuppea</i>
<i>C. caespiticia</i>	<i>L. chloromelum</i>	<i>P. subaurifera</i>
<i>C. capitata</i>	<i>L. corticola</i>	<i>P. subisidiosa</i>
<i>C. caroliniana</i>	<i>L. cyanescens</i>	<i>P. subrudecta</i>
<i>C. clavulifera</i>	<i>L. hirsutum</i>	<i>P. sulcata</i>
<i>C. coniocraea</i>	<i>L. saturninum</i>	<i>Pl taractica</i>
<i>C. cristatella</i>		<i>P. virginica</i>
<i>C. cryptochlorophaea</i>	<i>Lobaria pulmonaria</i>	<i>P. exasperata</i>
<i>C. didyma</i>	<i>L. quercizans</i>	
<i>C. digitata</i>	<i>L. scrobiculata</i>	<i>Parmeliopsis aleurites</i>
<i>C. fimbriata</i>		
<i>C. floerkeana</i>	<i>Menegazzia terebrata</i>	<i>Peltigera canina</i>
<i>C. furcata</i>		<i>P. horizontalis</i>
<i>C. incrassata</i>	<i>Nephroma helveticum</i>	<i>P. polydactyla</i>
<i>C. gracilis</i>	<i>N. parile</i>	<i>P. spuria</i>
<i>C. grayi</i>	<i>N. resupinatum</i>	
<i>C. macilenta</i>		<i>Physica aipolia</i>
<i>C. mateocyatha</i>	<i>Normandinea pulchella</i>	<i>P. orbicularis</i>
<i>C. merochlorophaea</i>		<i>P. phaea</i>
<i>C. parasitica</i>	<i>Parmelia appalachensis</i>	<i>P. pusilloides</i>
<i>C. pityrea</i>	<i>P. arnoldii</i>	<i>P. setosa</i>
<i>C. pleurota</i>	<i>P. aurulenta</i>	<i>P. stellaris</i>
<i>C. pyxidata</i>	<i>P. baltimorensis</i>	<i>P. subtilis</i>
<i>C. squamosa</i>	<i>P. caperata</i>	

*Platismatia glauca*  
*P. tuckermanni*

*Pseudevernia cladonia*  
*P. consocians*

*Pseudocyphellaria crocata*

*Pyconothelia papillaria*

*Pyxine soredata*

*Stereocaulon dactylophyllum*  
*S. pileatum*  
*S. tennesseeense*  
*S. ramulosum*

*Sticta fuliginosa*

*S. limbata*

*S. weigelii*

*Umbilicaria caroliniana*

*U. mammulata*

*U. muehlenbergii*

# # #

STUDY AND COLLECTION OF SALAMANDERS, NONGAME FISHES,  
AND OTHER NONGAME, SMALL VERTEBRATES (EXCLUSIVE OF BIRDS)

BLRI-N-22

INVESTIGATOR: L. M. Outten  
Mars Hill College

SUMMARY OF PROGRESS: Significant observations but no actual collections were made. On the basis of the work so far, it seems that the project should proceed as planned. The opportunity to observe and work in the area is greatly appreciated.

No specimens collected. No publications or reports on work under this permit.

# # #

GENETICS OF ISOLATED AND NONISOLATED POPULATIONS  
OF THE MOUNTAIN SALAMANDER, *DESMOGNATHUS OCHROPHAEUS*

BLRI-N-75

INVESTIGATORS: Stephen C. Tilley ) Collaborator, Smith College  
Charles O. McKinney) University of Dayton

SUMMARY OF PROGRESS: During 1973 I made no collecting trips to the Blue Ridge Parkway and moved from the University of Dayton to the University of Texas of the Permian Basin. From 1 January to 15 June, when I left the University of Dayton, I continued to carry out an electrophoretic analysis on animals collected during 1972. The emphasis was on microgeographic variation among populations along the parkway and the general vicinity. I examined variation between age classes, trying to determine the effects of selection. Dr. Tilley is continuing both of these areas of research since I am no longer in the area. A paper entitled Notes on lactate dehydrogenase variation in the salamander genus *Desmognathus* has just been submitted for publication in the journal *Copeia*. Dr. Tilley and I are in the process of writing up much of our other data. I am returning my collecting permit as I will not be able to continue work on this project except to write up the data we have already collected. Copies of all publications will be sent when completed.

## BRYCE CANYON NATIONAL PARK

### NESTING BIRDS OF THE YELLOW PINE FOREST AT BRYCE CANYON NATIONAL PARK, UTAH

INVESTIGATOR: R. H. Gerstenberg  
Reedley College

SUMMARY OF  
PROGRESS: In summer 1973 a study of the nesting birds in the yellow pine forest at Bryce Canyon National Park was continued. An analysis of the trees in the two study plots set up in 1971 showed that there were 558 trees per acre. The most abundant tree was Ponderosa pine (*Pinus ponderosa*) (92.6%) with Rocky Mountain juniper (*Juniperus scopulorum*), limber pine (*Pinus flexilis*), and Douglas-fir (*Pseudo-tsuga menziesii*) found in low numbers. Trees were measured according to size and the larger trees were also measured for diameter. Most trees (89%) were under 20 ft tall. There were 4.1 snags per acre found. Age of the larger trees varied between 90 and 200 years. Six bird censuses were taken in late June on the two study plots in the park and an equal sized logged area on Whiteman Bench outside the park. Twenty-eight species were found on the censuses, the most common being the Western Bluebird. Ten hole-nesting species were seen on the censuses, seven, including the Western Bluebird, were not found on Whiteman Bench. There was an average of 0.79 birds per acre found in the areas. Only 13 birds were trapped and banded in 1973. Two birds originally banded in 1972 were retrapped. This brings the total birds trapped in three summers to 399.

## BUFFALO NATIONAL RIVER

### PRELIMINARY RECONNAISSANCE WATER QUALITY SURVEY OF THE BUFFALO NATIONAL RIVER

INVESTIGATORS: R. E. Babcock     David Parker)  
                  H. C. MacDonald     Joe Nix     )  
                  Ken Steele         Ed Dale     )     Arkansas Water Resources Research Center  
                  Eugene Schmitz     Rick Meyer )

SUMMARY OF  
PROGRESS: Results from the preliminary reconnaissance indicate that continued monitoring of chemical, physical, and biological parameters of the river are necessary to define existing and potential sources of water pollution and to establish a set of baselines for determining any future water quality changes. A proposed work statement for FY 1974 is pending and it will establish a minimum of eight sampling stations along the river and its tributaries. These stations will be monitored a minimum of nine times during FY 1974. The following water quality parameters will be monitored; alkalinity, chlorides, coliform organisms, color, apparent conductivity, flow, hardness, iron, nitrogen, oxygen demand, oxygen, dissolved, pH, phosphorous, temperature, turbidity.

# CANYONLANDS NATIONAL PARK

## PLANT SYNECOLOGY OF CANYONLANDS NATIONAL PARK CANY-N-0004

INVESTIGATOR: Walter L. Loope  
Utah State University

SUMMARY OF PROGRESS: During the field season of 1973, vegetation and soil sampling was concentrated in the Needles and Island in the Sky districts. Sixty transects were run in the Needles and 50 on the Island in the Sky. Transect work has been completed, with a total of 220 spread throughout the park. A small amount of field work remains to be done this season; it involves digging soil pits and describing profiles in several areas.

The Needles District includes some habitats unique within the park; several of its drainages are fed by meltwater, precipitation, and ground-water flow from the highlands to the south (Blue Mountains and Elk Ridge). Salt Creek and Indian Creek are perennial streams while David, Horse, and Elephant canyons generally have water in spring and fall. Sampling efforts in the Needles was concentrated in major environmental situations as follows:

1. alluvial flats of Salt Creek and tributaries;
2. rocky slopes (skeletal soils) adjacent to major drainages;
3. park areas (deep eolean sand);
4. high elevation plateau remnants (e.g., Cedar Mesa); and
5. streamside.

Alluvial flats of Salt Creek support communities dominated by *Artemesia tridentata*, *Sarcobatus vermiculatus*, and *Atriplex canescens*. *Salsola kali*, *Cleome lutea*, *Bromus tectorum*, *Orizopsis hymenoides*, and *Sporobolus cryptandrus* are common in this situation also. *Chrysothamnus nausiosus* and *Chrysothamnus viscidiflorus* (rabbitbrushes) are present in small amounts. Big sage (*A. tridentata*) grows to 6 ft in the Big Picket in upper Salt Creek; greesewood (*S. vermiculatus*) and four-wind saltbush (*A. canescens*) grow to 4 ft with the favorable moisture regime of the flats. This type of habitat is common on upper and middle Salt Creek, Horse Canyon, Davis Canyon, Lavender Canyon, Lost and Squaw canyons.

Rocky slopes adjacent to these drainages are characterized by very shallow soils and support widely spaced *Juniperus osteosperma*, *Pinus edulis*, and shrubs *Artemesia bigelovii*, *Fendlera rupicola*, *Amelanchier utahensis*, *Cowania mexicana*, and *Cercocarpus intricatus*. Common herbs include *Hymenoxys acaulis*, *Penstemon eatonii*, *Brickellia scabra*; *Aristida fendleriana* and *Hilaria jamesii* are common grasses.

Park areas with deep eolean sandy soils support grasslands. In Chesler Park, a lightly disturbed area, *Bouteloua gracilis*, *Hilaria jamesii*, and *Stipa comata* dominate. In severely disturbed deep sand areas, such as parts of Devil's Lane, cheat grass (*B. tectorum*) and dropseed (*S. airoides*) are common grasses; Russian thistle (*S. kali*) is very common.

High elevation plateau remnants (e.g., Cedar Mesa) support closed Pinion-Juniper woodland. The understory includes buffaloberry (*Shepherdia rotundifolia*), *Amelanchier utahensis*, and other shrubs in small numbers.

Many mesophytes occur at streamside; sedges *Scirpus americanus* and several species of *Caryx*, grasses *Andropogon scoparius*, *Muhlinbergia asperifolia*, *Distichlis stricta*, and *Phragmites communis* are common. Goldenrod (*Solidago canadensis*), the small tree (*Forestiera neomexicana*), numerous *Salix* species, and *Populus fremontia* are also present.

Much of the area of the Island in the Sky is covered with blackbrush-galetta (*Coleogyne ramosissima*-*Hilaria jamesii*) vegetation that is also found in the Maze District (sampled

in 1972). Pinion-Juniper woodland covers much of the top of the "Island" interspersed with grasslands and some blackbrush areas. A unique habitat sampled on the island was that of low benchlands (4400 ft) on the west side of the district above the Green River. They are characterized by tight shale substrate and support an *Atriplex garrettia-Hilaria jamesii* community. The aggressive exotic, *Halogeton glomeratus*, is found in abundance on the east side of the White Rim and in small patches on abandoned roads in the district.

Field work is mostly completed at this time; synthesis, presentation, and explanation of the data are included in the next stage. I hope to have a rough draft of the project findings ready by mid-fall 1974.

# # #

ECOLOGICAL DISTRIBUTION OF MAMMALS IN CANYONLANDS NATIONAL PARK, UTAH  
CANY-N-0006

INVESTIGATOR: David M. Armstrong  
University of Colorado

SUMMARY OF PROGRESS: Progress to date includes extensive survey of small mammals in the Needles and Island in the Sky districts, and intensive study of ecological relationships of woodrats in the Needles District. A bibliography of reports, publications, and work in progress is appended.

On 3 January 1974, a research proposal was submitted to the National Science Foundation to support the completion of the survey of ecological distribution of small mammals in the park and to underwrite the preparation of the final technical report.

Future studies of small mammals in the park should detail competitive relationships among sympatric congeners (e.g., *Peromyscus*, *Neotoma*, *Myotis*) analyze population dynamics, and monitor successional trends during the recovery of native rangelands upon cessation of the intensive grazing by domestic livestock.

RECOMMENDATIONS: My recommendation would be that the National Park Service assume partial support of this potentially important work. The results may have implications for resource management, and surely they will be relevant to the interpretive function of the Service.

Bibliography:

- Armstrong, D. M. 1972. Mammals of Canyonlands National Park, Utah, I. Preliminary report of investigations, June-July 1972. Processed report for National Park Service.
- \_\_\_\_\_. 1973. Preliminary observations on mammalian faunal relationships, Canyonlands National Park, Utah. Paper presented to Zoology Section of 44th Annual Meeting, Colorado-Wyoming Academy of Science, Golden, 27 April. For abstract, see: *J. Colorado-Wyoming Acad. Sci.* 7(4):41-42.
- \_\_\_\_\_. 1973. Mammals of Canyonlands National Park, Utah, II. Preliminary report of activities, March, June-July, 1973. Processed report for National Park Service.
- \_\_\_\_\_. 1974. Second record of the Mexican big-eared bat in Utah. *Southwest Nat.* 18(1)

In preparation:

Habitat characteristics of the Mexican woodrat in southeastern Utah.  
Mammalian faunal structure, Canyonlands National Park, Utah.  
Ecological relationships of three sympatric species of woodrats in Canyonlands National Park, Utah.

Ecological distribution of mammals in Canyonlands National Park, Utah.  
Mammals of Canyonlands National Park, Utah: A distributional checklist.

# # #

RIVER USE ON THE GREEN AND COLORADO RIVERS IN CANYONLANDS NATIONAL PARK  
CANY-N-0007

INVESTIGATORS: John Hunt )  
James Kennedy )  
Lawrence Royer) Utah State University  
Stephen McCool)

SUMMARY OF The project is envisioned as a continuous one to be active over a 2-year,  
PROGRESS: or more, period. Due to limitations in funding, it is assumed that very  
limited detailed research can be conducted; rather an endeavor will be  
made to institute pilot projects which will provide interim guidelines to assist the  
Service with management decision-making. The ultimate objective of this project is  
comparative research to provide input for determining proper recreation capacity for  
recreation and wilderness use of the Colorado and Green rivers in Canyonlands National  
Park. This past summer in the field preliminary work was undertaken to assess the  
physical space limitations of the river system as they relate to providing space for  
camping and other terrestrial activities associated with river running. We recognize that  
this aspect of the project considers only one variable of many necessary to properly  
analyze recreation capacity.

CAPE HATTERAS NATIONAL SEASHORE

A SIMULATION MODEL AS A BASIS FOR ENVIRONMENTAL IMPACT ASSESSMENT

INVESTIGATORS: R. Gerald Wright  
Boyd Dearden

SCOPE OF An objective method for the assessment of the environmental impacts of  
STUDY: the proposed Cape Hatteras National Seashore management policy was  
established using as a base a compartmental simulation model. This  
particular problem lends itself quite well to the use of such a method in that the  
impacts of both the proposal and the alternatives could be delimited fairly clearly  
in a homogeneous environment.

In the course of establishing the model, 16 compartments were defined which represent  
the most important factors of the natural and socioeconomic environment which might be  
impacted. As an example, variables considered were residential and summer populations  
of the village enclaves, median income, visitation, percent land developed, terrestrial  
and estuarine productivity, and structural measures such as beach width and dune height.

The model structure was basically deterministic with some stochastic and mechanistic elements and was formulated by the method of Forrester.

The output was both tabular and graphic and was a 30-year simulation of the changes in the different compartments as a result of the proposed management strategy or of structural alternatives such as groins, dune lines, etc. The model contained a provision for varying the storm-frequency-intensity ratio. While still under formulation, the preliminary results have indicated its usefulness in impact assessment. The results of several alternatives can be compared both graphically or tabularly over a long time period, or a numerical coefficient placed in the traditional impact assessment matrix.

# # #

## BEHAVIORAL ECOLOGY OF ROYAL TERNS

INVESTIGATORS: P. A. Buckley  
F. G. Buckley

OBJECTIVES AND METHODS: Continuing our studies begun at CAHA in 1967 (see references) on various aspects of the behavior, ecology, and evolution of their attendant adaptations in Royal (and Sandwick) Terns, this year we were largely concerned with analysis of data obtained earlier and writing the last few papers in the series dealing with these fascinating birds that form such a highly visible and important part of the Outer Banks avifauna.

Our efforts were concentrated in three areas: (1) hexagonal nest packing; (2) comparative feeding ecology of wintering adults and juveniles; and (3) a recapitulation and overview of all our studies on these birds' biology.

RESULTS: (1) Hexagonal nest packing; early in our studies we noticed that Royal and Sandwich Tern nests seemed extraordinarily closely packed together, but inasmuch as we were working on other matters at the time, we filed away the data, only returning to it this year. The literature on natural packing of objects under high density is spotty, widespread, and generally old, although there have been some recent theoretical advances we were able to track down. We finally completed a paper showing Royals have achieved maximal density of their nests, resulting in a hexagonal configuration, the first demonstration of this effect in birds and possibly the first firm case from any vertebrate. We have made a strong case for their density being the result of predation on their eggs by Laughing Gulls, which, coupled with their one-egg clutches, indicates their potentially precarious situation. As the Outer Banks of North Carolina (CAHA & CALO) constitute one of their major breeding locations in the western hemisphere, the significance of these findings for management studies is obvious. The paper has been submitted to *Science*.

(2) Comparative feeding ecology of adults and young: as this species shows greatly extended parental care, we needed to look closely at feeding/foraging abilities of the two age-classes to see if juvenile foraging inability was responsible. We were able to locate proper study conditions on the island of Bonaire, Netherlands Antilles, where we went in two successive Januarys. Briefly, we found striking differences between adults and young in the components of their foraging, some of which had never been demonstrated and which have great theoretical interest. These include: adults forage about twice as fast over a given stretch of beach as juveniles, making about twice as many dives per minute as juveniles; although initial prey capture rates were the same in both age classes, the adults thereby caught more prey per unit time; both rarely dropped their prey without recovering it, but juveniles dropped their prey--subsequently recovering it--about 14 times more frequently than adults, thereby expending considerably more

energy per capture. Time budget analyses also showed significant, explainable differences, and we were able to demonstrate a significant inability of juveniles to recognize edible prey items, resulting in their higher mortality as well as reduced feeding success. This paper is in press in *Ecology*.

(3) Overview of Royal Tern biology: next we turned our attention to tying together all of our observations in one general paper emphasizing the selective factors responsible for the evolution of the various peculiar but nonetheless highly adaptive aspects of the species' biology. The resulting paper is now in press in *Scientific American*.

PLANS FOR 1974: Our studies of these birds are virtually concluded. We have now shifted our attention to their protection, especially at CAHA and CALO where they nest exclusively on vulnerable dredge spoil banks. We should emphasize that there is still much work to be done on both Royal and Sandwich Terns; we have just scratched the surface, calling attention to some of the more obvious aspects of their biology. We hope to be able to present one or two papers and show a movie to the XVIth International Ornithological Congress to be held this coming August in Canberra, Australia.

#### References:

- Buckley, P. A., and F. G. Buckley. 1969. Juvenile Royal Tern killing a conspecific downy chick. *Ardea* 58:95-96.
- Buckley, F. G., and P. A. Buckley. 1972a. The breeding ecology of Royal Terns *Sterna (Thalasseus) maxima maxima*. *Ibis*, 114:344-59.
- Buckley, P. A., and F. G. Buckley, 1972b. Individual egg and chick recognition by adult Royal Terns (*Sterna maxima maxima*). *Anim. Behav.* 20:457-62.
- Buckley, P. A., and F. G. Buckley. 1973. Hexagonal nest packing by Royal Terns [Aves: Laridae, Sterninae]. Submitted to *Science*.
- Buckley, F. G., and P. A. Buckley. 1974. Comparative feeding ecology of wintering adult and juvenile Royal Terns. *Ecology*. In press.
- Buckley, P. A., and F. G. Buckley. 1974. The evolution of a social system. *Sci. Am.* In press.
- Buckley, P. A. and J. P. Hailman. 1970. Black-headed Gull and five species of terns skimming water. *Br. Birds* 63:210-212.

# # #

### HABITAT USE BY "WATERBIRDS" AT CAPE HATTERAS NATIONAL SEASHORE

INVESTIGATORS: P. A. Buckley  
F. G. Buckley

OBJECTIVES AND METHODS: The role of "waterbirds" (*sensu lato* including wading birds, shorebirds, gulls, terns, skimmers, and to a small extent pelicans and allies) had received little attention at CAHA. Yet these birds are of prime importance to the coastal ecosystem, are readily and frequently interfered with by man, are the cause for significant numbers of visitors coming to the seashore, and we know little about where they are in the seashore at various times of the year. To fill in this gap, especially during the critical breeding season, we surveyed the entirety of CAHA, including all beachfront, by 4WD vehicle, car, boat, plane, and even Coast Guard LARC. We were in the field during June (breeding season) and September (fall migration).

RESULTS: Our results are fully outlined in the two documents listed below, which will be summarized here.

Breeding birds were carefully censused, since there were no real data on what species, let alone how many of each, were breeding at CAHA, or where. We found some 6650 pairs of waterbirds breeding in the area between Oregon and Ocracoke inlets, including on

spoil islands in these and Hatteras inlets, but for logistic reasons only, from no points north or south of Oregon and Ocracoke inlets (Table 1).

Table 1

Species	# Breeding Pairs	# Breeding pairs on main barrier beach
Brown Pelican	35	
Little Blue Heron	1	
Snowy Egret	151	
Louisiana Heron	210	
Black-crested Night Heron	3	
Glossy Ibis	1	
American Oystercatcher	103	
Wilson's Plover	10	10 (10) <sup>a</sup>
Piping Plover	2	2 (2)
Willet	27	5 (5)
Herring Gull	4	
Laughing Gull	851	
Caspian Tern	2	
Royal Tern	3600	
Sandwich Tern	450	
Gull-billed Tern	65	19 (19)
Common Tern	625	104 (100)
Forster's Tern	119	4 (3)
Least Tern	115	115 (60)
Black Skimmer	<u>280</u>	<u>71 (65)</u>
Totals:	6654	329 (264 or 80.2%)

<sup>a</sup>Figures in parentheses are number of breeding pairs on Ocracoke Island alone.

While the figures do not include ca. 1000 pairs of Laughing Gulls on Gull Island in the sound behind Avon or any of the numerous breeding herons and ibises, stilts, avocets, etc., on Pea Island NWR (inside the statutory boundaries of the seashore but administered by the F & W Service), they are nonetheless most impressive. Included are some items not immediately obvious: (1) the Ocracoke Inlet pelican colony is not only the northernmost in North America, but one of the few still untouched by pesticide problems or reduced fecundity; (2) Piping Plover, Herring Gull [Great Black-backed Gull, just north of Oregon Inlet, on a spoil island], and Common Tern all reach the southern limits of the North American distribution at CAHA; (3) Forster's Tern was found breeding only in North Carolina for the first time in 1972, and yet look at 1973 figures; (4) the two pairs of Caspian Terns in the Royal colony at Oregon Inlet is the first proved North Carolina breeding, and only the second known in this century from the Atlantic Coast; (5) the three Royal/Sandwich Tern colonies at or near the three inlets are among the most productive and stable on the East Coast, where there are probably less than a dozen such colonies.

The most disturbing aspect of our censusing is evident from the table, viz., the numbers, and percentages, and breeding waterbirds that are restricted to spoil bank islands in the inlets and sounds: 95% or some 6325 pairs of waterbirds, excluding the additional 1000 pairs of Laughing Gulls on Gull Island. These birds have no doubt been forced there by human disturbance, especially beach vehicle traffic, and by loss of proper habitat as the beach berm has become steep and narrow where a natural overwash condition has not been allowed to obtain. It is not by accident that of the 329 pairs of waterbirds we did manage to find nesting on the main barrier beach itself, 80% of them were on Ocracoke Island, reachable only by ferry, having little beach access, and especially at the south end where virtually all the seabirds were breeding, still in essentially a natural overwash condition. The implications for still-natural beach areas such as CALO, GUIS, and CUIS are manifest.

Fall-migrating birds, on the other hand, made little use of the spoil banks except for high-tide roosting. They did show the same preference for the superb flats on the

south end of Ocracoke Island that breeding birds did, and for the same reasons. To a lesser extent they favored the extensive Oregon Inlet flats (north side), but as migrants they could take advantage of tidal flux exposing other suitable areas and flee if disturbed at the inlet; an option not open to any birds attempting to breed on those same flats. As during the breeding season, the areas immediately surrounding Hatteras Inlet had virtually no avian use other than high-tide roosting, due at least as much to unsuitable habitat as to very heavy human disturbance. The greatest species diversity and numerical abundance were found as follows: (1) in salt water/tidal flat conditions, at Ocracoke, and to a lesser degree, Oregon inlets; (2) in fresh/brackish shallow pools, at Bodie Island Lighthouse pond, and to a lesser extent, in the pools on Pea Island NWR; (3) in dry, short-grass sand flats, on the Pea Island NWR grass flats (dry pools), and to a lesser extent on the extraordinary *Salicornia* flats on the south (actually the west) end of Ocracoke Island, immediately adjacent to the tidal flats discussed earlier. The total worth of these combined areas, just in terms of shorebirds, can be gauged from our recording some 37 species in the brief period we were there in September--almost every species ever seen in the state of North Carolina, some of them quite rare.

**CONCLUSIONS:** We recommended, in brief, that every effort be made to include all inlet spoil island within CAHA/CALO statutory boundaries, on the simple grounds that if 95% of CAHA's waterbirds are nesting on them, they ought to be part of the seashore. At present, they are generally state-owned, unposted, or otherwise protected, subject to human disturbance as the height of the boating season coincides with the height of the birds' breeding season, and to add insult to injury, subject to spoil deposition even when covered with breeding birds. We also recommended that existing salinity and depth conditions at Bodie Island and Pea Island NWR pools be carefully maintained; that varying degrees of closure of the Ocracoke Flats be investigated during the breeding season and perhaps during migration as well; and that it is unlikely that there will be any significant increase in species breeding on the main barrier beach between Hatteras and Oregon inlets (some 55 miles) unless beach traffic is drastically reduced or eliminated entirely and the beach is allowed to revert to a natural overwash condition.

**PLANS FOR 1974:** As a result of our discovery of the significance of spoil banks to the breeding biology of CAHA seabirds, we have gotten together with some colleagues also working on spoil banks and are planning to hold a conference on Spoil Bank Biology at CAHA in early June, with interested/concerned officials from the Corps of Engineers, NPS, BSF&W, State of North Carolina, local universities, etc., attending. We hope to have field trips to the spoil banks, taking that opportunity to repeat and extend our breeding bird censuses. They must become an annual event, with the National Park Service ultimately taking responsibility for gathering and promulgating the data.

We are also planning to write two papers relevant to this topic: one on beach use problems and colonially nesting birds. Many colleagues have contributed their information, so they will be compendia of observations going back many years.

#### RELEVANT DOCUMENTS:

Buckley, P. A., and F. G. Buckley. Colonial sea-, shore-, and water-birds breeding at Cape Hatteras National Seashore, and related problems. 11 p MS-report to CAHA Supt., dated 9 July 1973.

\_\_\_\_\_. Shorebird use at CAHA & CALO in fall migration, and related problems. 11 p MS-report to CAHA & CALO Supts., dated 1 Dec. 1973.

# CARLSBAD CAVERNS NATIONAL PARK

## AIR POLLUTION FROM BIRD NESTING IN CAVE

INVESTIGATOR: Gary M. Ahlstrand  
National Park Service

SUMMARY OF PROGRESS: Soil samples containing Cave Swallow fecal matter were collected at the natural entrance to the caverns and sent to the ESL, MTF for identification of pathogenic microorganisms possibly present in the samples.

SIGNIFICANT FINDINGS: No significant findings have been received to date.

RECOMMENDATIONS: Recommendations regarding the future course of action await final results of the analysis being conducted at the ESL.

# # #

## MICROORGANISM SURVEY IN SOIL AND DEBRIS FROM CARLSBAD CAVERNS

INVESTIGATOR: Donald E. Gardner  
National Park Service Science Center

OBJECTIVES: To evaluate microorganisms populations found within Carlsbad Caverns with particular emphasis on discovering potential human pathogens.

METHODS: Fluid dilutions of soil and debris collected in Carlsbad Caverns were made and plated on various selective media for the determination of specific groups of bacteria and fungi.

RESULTS AND DISCUSSION: Although the investigation is still in progress, no microorganisms have yet been isolated and identified which are normally considered as severe threats to human health. Bacteria thus far discovered have been *Staphylococcus* sp., *Escherichia* sp., and other common rods and cocci. Fungi isolated have belonged to the *Aspergillus glaucus*, *A. versicolor*, *A. nidulans*, and *A. niger* groups. *Penicillium* sp. and other commonly encountered fungi were also present.

As mentioned above, further work with selective media is currently in progress. Definite conclusions may, therefore, not be drawn at this point.

# # #

## CAVE CLIMATE CACA-N-001a

INVESTIGATOR: U.S. Geological Survey  
Albuquerque, New Mexico

SUMMARY OF        Data have been collected and reduced to evaluate the effect of sealing the  
PROGRESS:        elevator shaft on the cave microclimate. The data have been prepared in  
                  punched-card format for computerized statistical reduction of cave  
microclimate parameters. The final report is in preparation.

Significant findings are contained in The Microclimate in Carlsbad Caverns, and in  
the report now in preparation.

The final report will be finished shortly after 1 January 1974.

# # #

CEUTHOPHILUS ACTIVITY RHYTHMS  
CACA-N-002

INVESTIGATOR:    Glenn D. Campbell  
                  Texas Tech University

SUMMARY OF        Using mark recapture techniques, *in situ* observations, and statistical  
PROGRESS:        analysis, the aggregation, dispersion, and periodic movements of  
                  several species of cave crickets (*Ceuthophilus conicaudus*, *C.*  
*carlsbadensis*, and *C. longipes*) within two caves of Carlsbad Caverns National Park  
(Water Tank Cave, Spider Cave) were investigated in 1973.

In 1973 I undertook a mark recapture census at Spider Cave to determine the  
population number of cave crickets within this cave. The Lincoln-Peterson Index with  
the Bailey modification was used to calculate the population number (10,098-13, 116).  
A monthly population fluctuation was noticed, with low counts being for fall and  
winter months of this year. Entrance observations were made and it was noticed that a  
nocturnal migration was initiated at sundown. Additional observations will be made to  
completely characterize this migration. Pit traps were placed surrounding the  
entrance and it was noticed that the crickets foraged a considerable distance from the  
entrance during their nocturnal migrations.

The following are several observations and experiments that I will perform this  
coming year:

- Spatial and temporal temperature and relative humidity recording.
- Seasonal population fluctuations.
- Daily movements of individuals.
- Nocturnal movements of individuals.
- Reproductive cycle observations.
- Selection experiments (substrate, relative humidity and temperature).
- Animal associations.

# # #

CAVE SURVEYING  
CACA-N-005

INVESTIGATORS:  John Corcoran)    Cave Research Foundation  
                  James Hardy  )

SUMMARY OF            A total of six major and two minor expeditions were fielded during 1973.  
PROGRESS:            Cave areas that received particular attention this year are listed below:

- Carlsbad Caverns National Park (CCNP)
- Carlsbad Caverns:
  - Lower Cave Maze
  - Mabel's Room Boneyard Area
  - Big Room
  - Left Hand Tunnel
- New Cave
- Midnight Goat Cave
- Lake Cave
- Spider Cave
- Christmas Tree Cave
- Water Tank Cave
- Guadalupe Mountains National Park (GMNP)
- Heigler Goat Cave
- Majestic Ice Cave

In addition to the caves mentioned above, much surface surveying was done in order to establish baseline surveys. Surveys in the New Cave/Midnight Goat Cave area, both underground and on the surface, are to be considered the most significant findings due to the recent opening of New Cave to tour groups. A preliminary draft of the map has been completed and the majority of the field work on these two related caves has been finished.

For 1974 the same level of effort is planned and will take place both in Carlsbad Caverns and other caves in the two parks.

# # #

LOCATION AND INVENTORY OF CAVES  
CACA-N-006a

INVESTIGATOR: Charles M. Peterson

SUMMARY OF            I have continued to examine systematically backcountry areas of the park  
PROGRESS:            for caves. I have visited many known caves up-dating their individual  
                         files.

Two new caves have been added to the park files, bringing a total of 59 known caves. I have spent about 50% of my time on this ground reconnaissance.

I have arbitrarily set a 5-year time span for the ground reconnaissance and inventory of caves. During these years I will extensively cover the caverns backcountry; however, one can be assured that new caves will continue to be found after this project due mainly to the ruggedness of the park.

# # #

ROCK FORCES IN CARLSBAD CAVERNS  
CACA-N-009

INVESTIGATOR: U.S. Geological Survey  
                 Alburquerque, New Mexico

SUMMARY OF            Data are being collected from three strainage transducers placed in the  
PROGRESS:            caverns near the lunchroom.

A maximum displacement of about 0.001 inch has been measured.

This project will be terminated and a final report prepared by 1 January 1974. The equipment will be left in place for NPS information, if interest warrants.

# # #

NATURAL ECOLOGIC SURFACE CONDITIONS-PART A WILDFIRE  
CACA-N-011a

INVESTIGATOR:    Gary M. Ahlstrand  
                  National Park Service

SUMMARY OF            This study will run concurrently with GUMO-N-9, Natural Ecologic  
PROGRESS:            Conditions-Fire.

A laboratory for controlled environment studies is being set up at Carlsbad Caverns National Park. Seeds of several dominant species were collected for germination studies that will commence when the equipment for the study has been constructed.

Old natural burn sites are being sought so that permanent plats can be established to follow successional trends.

It is hoped that equipment and materials can be acquired soon so that the study can be well under way by April 1974.

# # #

INTERAGENCY BROWSE RANGE ANALYSIS SURVEY  
CACA-N-012

INVESTIGATORS:    Mike Glass  
                  Roger Reisch

SUMMARY OF            Field work completed and analysis of data completed. A few more maps  
PROGRESS:            depicting transect data are to be made.

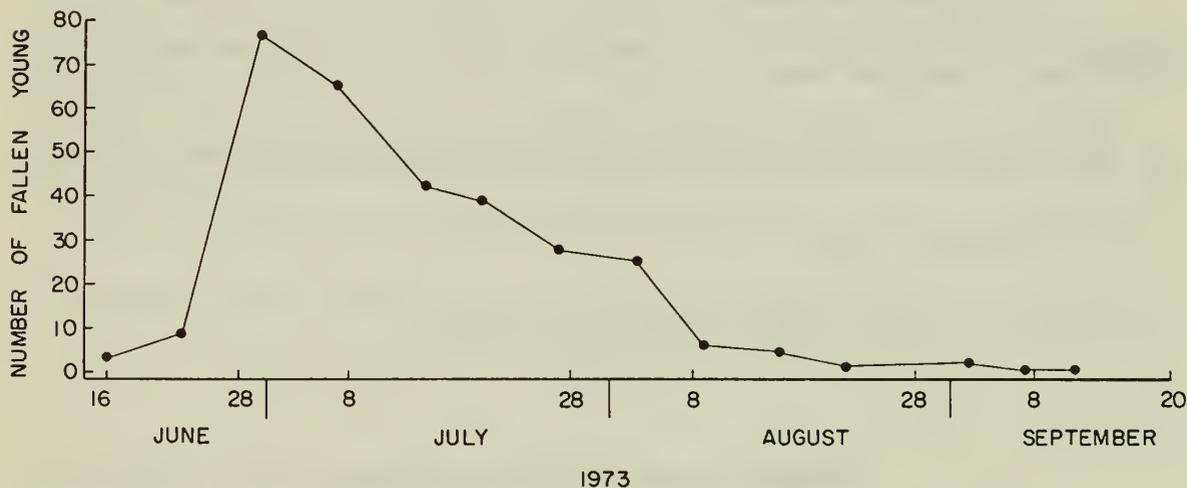
SIGNIFICANT            Same as GUMO project; more information listed of summary report for  
FINDINGS:            CACA written last year.

RECOMMENDATION:    Continuation of fence line past Danny Colwell's.

INFANT MORTALITY OF *TADARIDA BRASILIENSIS* AT CARLSBAD CAVERNS IN 1973  
CACA-N-13

INVESTIGATORS; J. Scott Altenbach) University of New Mexico  
Kenneth N. Geluso )  
Don E. Wilson ) National Museum of Natural History

SUMMARY OF PROGRESS: The *Tadarida brasiliensis* nursery colony at Carlsbad Caverns was visited at weekly intervals throughout the 1973 reproductive season. All fallen infants were collected from the guano piles and floor below the roost during two consecutive mornings of each visit. By constructing a graph depicting the number of infants that fell in 24 hours during each visit, infant mortality for each day could be estimated by interpolation (Fig. 1). We estimated that 2050 young of this year fell. This represents 0.9-2.8% of the total number of young born (we will be more precise in the percentage after our photographic population estimates are completed).

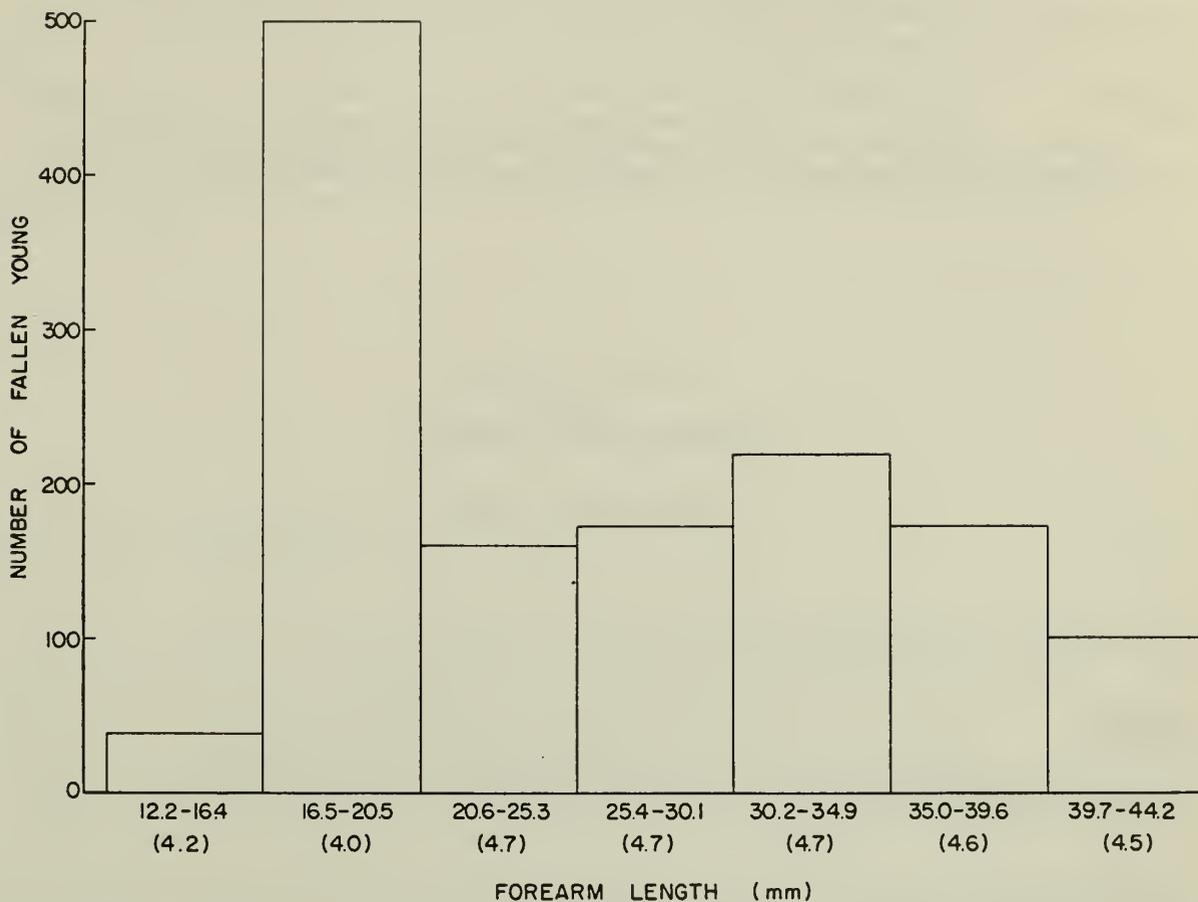


Forearms of all infants collected were measured to determine the size class (= age group) with the highest mortality. A histogram was constructed by dividing the range of forearm measurements into seven class intervals and then determining the number of fallen infants belonging to each size class (Fig. 2). At this time we do not know why the second size class (= infants from birth to 2 days old) has a much higher mortality. The data, however, suggest that the critical period may be within the first hour after birth when the infant first tries to attach to its mother or ceiling. The possibility that younger bats would be more prone to become inadvertently dislodged or slip because they are less coordinated and weaker than older bats does not appear to be true. Just as many 3-12 day old infants (size class #3) fell as 30-29 day old infants (size class #6).

In the next few months, infants from each size class will be analyzed for pesticides and heavy metals. Depending on these results and on future observations of infant mortality patterns at Carlsbad Caverns, this year's infant mortality may prove to have been at a normal level for this species. This would provide an important base line on which all future studies could be compared.

It should be emphasized that Carlsbad Caverns provide a unique *T. brasiliensis* roost for the study of infant mortality since it does not harbor the flesh-eating dermestid beetle. This allows the procurement of valuable data from the relatively untouched fallen infants. Such data will help us piece together the causes for the pattern of infant mortality displayed. Thus, we plan to continue investigating the magnitude and

patterns of infant mortality at Carlsbad Caverns as part of our study to determine the factors affecting declines in populations of *T. brasiliensis*.



### CHACO CANYON NATIONAL MONUMENT

#### HYDROLOGY OF CHACO CANYON NATIONAL MONUMENT AREA

INVESTIGATOR: Garland Moore

OBJECTIVES: To update information on the availability and appraisal of groundwater for planning and managerial purposes.

METHODS: Field surveys and literature review have been made to gather information for this study. Additional surveys will be conducted. Drilling of test wells (deep and shallow) will be used to determine the structural and lithological character of subsurface geology.

RESULTS AND DISCUSSION: Compilation of all hydrological and geohydrological data still in progress. Water demand projection until the year 2020 is estimated to increase at an average annual rate of 20,500 gallons per year with the present development (1,480,000 gpy in 2020). Alternative measures for the protection of groundwater in the area--no action.

PLANS FOR 1974: 1. Continue compilation of hydrological and geohydrological data--complete report. 2. Complete water demand projection until the year 2020 with graphic projection for yearly and monthly water demand. 3. Begin to identify alternative measures for the protection of groundwater in the area.

## CHIRICAHUA NATIONAL MONUMENT

### RESEARCH NATURAL AREAS

INVESTIGATOR: William Moir  
Arizona Academy of Science

SUMMARY OF PROGRESS: Dr. Moir spent 2 days in the field gathering basic data on the five Research Natural Areas located at Chiricahua National Monument. His purpose was to prepare a basic description of each natural area for the Arizona Academy of Science which is publishing a directory to the Research Natural Areas for the Arizona State Government.

In his description of each of the five natural areas at Chiricahua, Dr. Moir included the following: location, access and accommodation, climate, geology and topography, biota, research and educational value, and references.

# # #

### GEOLOGY IN CHIRICAHUA NATIONAL MONUMENT

INVESTIGATOR: Richard P. Yetman  
Chiricahua National Monument

SUMMARY OF PROGRESS: The principal goals of this project are to survey available materials and combine them with necessary field work to provide (1) a published pamphlet for the lay visitor on the geology of Chiricahua National Monument, and (2) a technical published field report on the geological picture at Chiricahua National Monument.

Several studies have been undertaken over the years on the geology of Chiricahua National Monument, but, although these studies are complete for the most part, they deal with individual units within the monument and no study has incorporated all of the others; therefore, no complete or comprehensive study has been done.

All of the available resource material has been studied to produce more complete background than has been available. Several discrepancies have been found, most of which have been ironed out by field work. For example, an Oligocene Lake Bed, originally researched and mapped to have a horizontal extent of about 400 yards, has been found to extend well over one mile and perhaps much more. This and other findings along with previous research should soon be published in a geological pamphlet for visitor hand-out.

The above progress has been limited to 2 days a week. In order to compile a complete and thorough investigation of the geology of Chiricahua National Monument and a technical geological report, funding should allow full-time geological work in the area of 3 months' duration.

# # #

### ECOLOGY OF THE COATI CHIR-N-1

INVESTIGATOR: Dirk Lanning  
The Evergreen State College

OBJECTIVES: To determine the daily and seasonal movements, individual and band habits, effects of weather and snowfall, presence of winter lethargy, and population of the coati (*Nasua narica*) within Chiricahua National Monument. The results will be used in the management and interpretation of this species for the monument.

METHODS: Field observations of individuals and bands are made whenever possible. Animals are live-trapped and color-marked for individual identification with colored ear tags and colored tape around the tail. Animals will be instrumented with radiotracking equipment to facilitate location and observation.

RESULTS AND DISCUSSION: This study was initiated in the fall of 1973. Trapping techniques were developed. A color-coded marking system was devised and is working satisfactorily. Anesthetics were researched and have been used successfully on 11 animals. The radio telemetry system was designed and is under construction.

Visual observation was found to be very difficult in the rugged terrain and heavy brush of the monument. Observation of moving animals by direct following has not been possible. Trapping has been more successful. Eleven coatis have been live-trapped and color-marked. Four have been recaptured one or more times. Two have been sighted at least once since marking.

PLANS FOR 1974: Continue live-trapping in several areas of the monument. Radiotracking equipment will become available early in 1974 and is planned to facilitate visual observations. The project will be concluded next fall. A comprehensive report will be submitted by the end of 1974.

# CRATER LAKE NATIONAL PARK

## BLACK BEAR STUDY AND MANAGEMENT IMPLICATIONS CRLA-N-2A

INVESTIGATORS: Michael T. McCollum  
James A. Blaisdell

OBJECTIVES: Management recommendations based upon black bear studies dating back to 1944 and 1969 include as the first step the closure of all garbage dumps in the park. These recommendations were to be carried out during the winter 1971-72 and continued. Scope of the study includes those listed for the original RSP-CRLA-N-2: "To determine the habits, population, longevity, reproduction and other pertinent ecological characteristics of the black bear in and near the park, the results to be used in the management (including the bear problem)" and interpretation of this species for the park.

1. Determine the reactions of bears to the closure of all garbage dumps in the park.
2. Obtain an estimate of total bear numbers in the park.
3. Determine which bears are nuisance or dangerous bears.
4. Provide information on numbers of park bears which may be harvested by hunters on adjacent lands, and the effects of hunting on park bear populations.

The study is meant to show primarily the changes in bear feeding habits and tendencies toward property damage and personal injuries because of dump closures. Studies of this type have been accomplished previously in several parks, but in this case, all dumps are to be closed at one time and permanently. This may or may not change the bears' habits.

METHODS: Objectives of the study were well met during studies carried out during the summers 1971-72. During 1972-73, an attempt was to be made to learn of the population and actions of wild bears. Mr. McCollum was to trap or otherwise capture wild bears, and monitor their movements through to hibernation by the use of radio telemetry equipment. No bears were to be released outside the park.

RESULTS AND DISCUSSION: Great effort was expended in attempts to capture wild bears. Although a good number of bears was captured, many were nuisance bears or were bears too small to place a collar on. McCollum's greatest problem appeared to be in keeping the collars in place. So often, the neck was as large as the head. Placement of Velcro on the inside of the collar did not solve the problem. A run-down of animals collared appears below:

<u>Bear No.</u>	<u>Date Collared</u>	<u>Remarks</u>
M323	July 11	Shed August 1 collar found
M331	Aug. 7	Collar malfunctioned - lost
M334	Aug. 24	Shed Aug. 28 collar found
M323	Sept. 21	Located daily until Oct. 12 No signal since.
M335	Sept. 22	Located daily until Oct. 12 No signal since.

A good record of home range was obtained from M323 and M334. Their range was small, not over 5 miles. A copy of McCollum's final report will be submitted when it is prepared in final form.

CONCLUSIONS: The total number of wild bears in the park is probably small, and does not add much to the sportsman's bag outside the park. Some problems with nuisance bears recurred in 1973, primarily because the park was not bear-proofed. These problems will continue so long as garbage is easy to obtain, and people do not keep food in proper containers.

PLANS FOR 1974: Because of the limited number of bears actually tracked, it is hoped we can continue the study for one additional year. This involves locating and hiring a new seasonal employee to replace McCollum, who has become a permanent employee.

# # #

NATIONAL NETWORK OF HYDROLOGIC BENCHMARKS  
CRLA-N-0006

INVESTIGATOR: U.S. Geological Survey

SUMMARY OF PROGRESS: Continuing to collect samples of lake water and make chemical quality analyses periodically (about 3 or 4 times per year). Collecting daily maximum and minimum water temperatures. All of this is under the Hydrologic Benchmark program.

# # #

SMALL MAMMAL DISEASE SURVEY  
CRLA-N-0008

INVESTIGATOR: Robert A. Gresbrink  
Oregon State Health Division

SUMMARY OF PROGRESS: The small mammal disease survey is conducted biennially (in the case of animal die-offs, investigations as required) on a routine basis.

SIGNIFICANT FINDINGS: The survey was conducted in September 1973. Although the laboratory results from ectoparasites submitted for testing have not been received, the small animal population observed appeared healthy and normal.

RECOMMENDATIONS: That the surveys be continued at present level.

# # #

POPULATION AND TREE DAMAGE TRENDS OF THE BALSAM WOOLY APHID IN SUBALPINE FIR  
CRLA-N-0011

INVESTIGATOR: R. G. Mitchell  
U.S. Forest Service

SUMMARY OF PROGRESS: Plots not evaluated in 1973. I plan an assessment every 2 years in the future.

RESOURCES STUDY PROBLEM: ELK, THEIR ECOLOGY AND MANAGEMENT  
CRLA-N-15A

INVESTIGATORS: Michael T. McCollum  
James A. Blaisdell

OBJECTIVES: Elk occur in sections of the park during the warmer seasons of the year. Little is known of the total population, distribution, migration routes and dates, and other information necessary for proper interpretation and management both within and outside the park. Henley (CRLA-N-15) reported on his activities during an elk survey 15-19 July 1970. He presented no estimate of total population or total range and range condition. It was proposed that with cooperating agencies (Oregon Game Commission and U.S. Forest Service) we determine the following:

1. Subspecies of elk inhabiting the park
2. Population, reproduction, and survival of elk
3. Migration directions and seasons
4. Principal range and condition
5. Management occurring and needed
6. Possible interpretive data

The purpose of the project is to determine the many unknowns regarding elk in Crater Lake National Park. Total expenditures of time and funds for this study remain low although more effort has been put forth this year than last.

METHODS: All research carried out has been via the reconnaissance method, with numbers and locations of animals being recorded as well as range utilization being observed. Most of the park has now been walked over, and elk numbers estimated.

RESULTS AND DISCUSSION: Final report by McCollum is due soon. By keeping count of actual sightings plus track counts, it is estimated that there are approximately 100 Roosevelt elk summering in the park. The largest concentration (but not by much) occurs in the southwest corner (Union Peak). Elk are found in all four corners of the park.

Migration from the southwest corner appears to be toward Red Blanket Creek. Other migration patterns are as yet unknown. Counts have been too few to determine accurately cow:calf ratios or survival rates. Indications are that the entire population of elk in this area--both inside and outside the park--is increasing rapidly.

A Cooperative Biological Unit Habitat Management Plan for the Butte Falls-Prospect Elk Herd has been prepared and agreed to by this office. Others involved are the Rogue River National Forest, the Bureau of Land Management, and the Oregon Game Commission. Study responsibilities are spelled out for each agency.

CONCLUSIONS: Data has been gathered for two summers, but more is needed. In fact, according to our cooperative agreement (above), we need to present data at an annual meeting. This means collecting each summer.

PLAN FOR 1974: Continue studies as required.

## CRATERS OF THE MOON NATIONAL MONUMENT

### OXYGEN ISOTOPE GEOCHEMISTRY OF BASALTS FROM THE SNAKE RIVER PLAIN, IDAHO

INVESTIGATORS: Karlis Muehlenbachs) Geophysical Laboratory, Washington, D.C.  
George T. Stone ) University of Oklahoma

SUMMARY OF PROGRESS: As part of an ongoing study of  $O^{18}/O^{16}$  variation in the volcanic rocks of the Snake River Plain, I collected parts of acidic xenoliths in the basalts of North Crater, Crater of the Moon National Monument. I shall determine the oxygen isotope ratios of the xenoliths and their host basalt in order to determine if some of the compositional peculiarities of the basalts are due to assimilation of old basement rock.

An interesting side light of this work is that it may be possible to calculate the time that the xenoliths were in contact with the lava. At Square Mountain, a few miles west of the Monument, I have calculated on the basis of isotope contents of xenoliths, phenocrysts in the lava, and diffusion coefficients that gneissic xenoliths found there have been in contact with the lava 3 to 6 years. I will try to do similar calculations with the North Crater material.

# # #

### MAGNETIC SECULAR VARIATION OF GREAT RIFT BASALTS

INVESTIGATORS: Duane Edwin Champion) California Institute of Technology  
Eugene Shoemaker ) CalTech and Branch of Regional Geophysics-USGS  
Donald Watson ) U.S. Geologic Survey, Boulder, Colorado

SUMMARY OF PROGRESS: We are quite pleased with the quality of data that I took along the Great Rift Basalts this past summer. It seems consistent between different flows and fields and also within itself. A problem exists though in that I usually only have a single sampling site per flow and I have no check as to its correctness. What I need to do is sample each flow in duplicate so I can be sure that my data is correct. This is basically what I intend to do next summer. Also here at CalTech we are not a functioning laboratory quite yet but we expect soon to be fully operative.

# # #

### STUDY OF ACCESSORY MINERALS IN PRIMARY VOLCANIC ROCKS

INVESTIGATORS: William D. Romey Don Chase )  
James Underwood William T. Elberty, Jr.) St. Lawrence University  
Bruce Carhart Steven Daily )

SUMMARY OF PROGRESS: The materials we collected at the Craters of the Moon National Monument during the summer of 1973 are to be studied as part of a project dealing with accessory minerals in volcanic rocks. Reference suites have been collected in several other volcanic terranes in the northwestern United States. The

materials from the Craters of the Moon have not yet been subjected to detailed examination. Ultimately they will be thin sectioned and an attempt also will be made to separate out accessory minerals for detailed mineralogical study.

I hope that during the course of spring 1974 it may be possible for us to begin on these materials. We have large amounts of materials from other locations as well, and the order in which we will study these separate collections has not yet been set. If one of our student investigators happens to choose the Craters of the Moon materials, we may get to work on them very soon. On the other hand if some of the other collections are chosen first it may be some time before Craters of the Moon rocks are examined in detail.

We shall be pleased to provide copies of our data when we have data in hand.

## DEATH VALLEY NATIONAL MONUMENT

### PHYSIOLOGY OF MAN IN EXTREME HEAT

INVESTIGATOR: David B. Dill  
University of Nevada System

SUMMARY OF We continued desert studies in Boulder City in the summer of 1973. We  
PROGRESS: hope to spend a few days in Death Valley in the summer of 1974.

# # #

### GEOLOGIC MAPPING OF TELESCOPE PEAK QUADRANGLE

INVESTIGATOR: Arden L. Albee  
California Institute of Technology, Pasadena

SUMMARY OF A preliminary copy of the map was compiled and sent to the state for  
PROGRESS: their use in revising the 1:250,000 scale Death Valley sheet. A copy  
has been sent to you.

A manuscript by Doug McDowell will be published this year in *Geol. Soc. Am. Bull.*  
It was part of a Ph.D. Thesis done under my direction on the Little Chief stock on  
Telescope Peak.

A graduate student, Ted Labrtka, has begun mapping on the west side of the Panamint Range to fill in gaps in our mapping of the Telescope Peak quadrangle. He will probably do some work in the Funeral Mountains as well at a later stage.

## PETROGRAPHY OF OWLSHEAD MOUNTAINS

INVESTIGATOR: James Calzia  
University of Southern California

SUMMARY OF My M.S. Thesis manuscript is being reviewed for content, grammar, and  
PROGRESS: punctuation. Briefly, the purpose of the thesis is to describe the  
petrography and petrology of plutonic rocks in the southeastern Owlshhead  
Mountains. Field and mineralogical evidence suggest the Owlshhead pluton crystallized at  
the shallow crustal levels, at temperatures greater than 800°C, and contained 2-4%  
water by weight.

# # #

## SILURIAN CONODONTS

INVESTIGATORS: Richard H. Miller) San Fernando Valley State College  
Frank M. Hanna )

SUMMARY OF Collection and processing of samples of Silurian rocks from the northern  
PROGRESS: part of Death Valley are essentially complete. This is the major portion  
of R. Miller's dissertation. However, this work has indicated a need  
for wide-scale changes in the Ordovician through Devonian Stratigraphy of the entire  
southwestern Great Basin based on various microfossil groups which have not been  
studied in this region.

Future extensive research involving collection of samples from measured sections in  
the Death Valley region is planned for the next few years during fall, winter, and  
spring seasons.

An extensive series of publications covering this completed and future research  
program will be made available when completed.

# # #

## GEOLOGY OF SKIDOO-TUCKI MOUNTAIN AREA, PANAMINT RANGE

INVESTIGATOR: Edward W. Hildreth  
University of California, Berkeley

SUMMARY OF Detailed mapping of the Precambrian and Paleozoic has been delayed by  
PROGRESS: work on other projects. About half complete, the Tucki-Skidoo map is  
now a long-term project which will require periods of several weeks  
at a time over a period of years, scheduled as other duties permit.

Current laboratory research on granite phase equilibria includes work on specimens  
from the Paramint Range.

## MOVING ROCKS ON RACETRACK PLAYA

INVESTIGATOR: Robert P. Sharp  
California Institute of Technology

SUMMARY OF  
PROGRESS: Please see the statement filed with Peter G. Sanchez, Resources  
Management Specialist, Death Valley National Monument, on 19 July 1973,  
for the results obtained last winter and the current status of this  
project.

# # #

## ECOLOGY OF DESERT ANNUALS

INVESTIGATOR: Frits Went  
University of Nevada, Reno

SUMMARY OF  
PROGRESS: Due to an unexpected rainy winter, more work was carried out this year  
on germination and survival of desert plant seedlings than had been  
anticipated. Survival of the seedlings which germinated early after  
the 4 October rain was less than 50%, but later germinations were at a very much higher  
rate.

During summer, Dina Mandoli carried out a number of germination studies on seeds  
collected last spring in Death Valley and found that all these winter annuals germinated  
best at low temperatures as expected. She also found that in a number of cases  
germination was enhanced by the use of charcoal in the germination containers and in  
a few a short, high temperature treatment increased germination. She also germinated  
seeds derived from a harvester ant nest. One seed which we had been unable to identify  
turned out to be *Chenopodium pumilio*, a weed which I had not previously observed in  
Death Valley and of which there was no herbarium material at the University of Nevada  
herbarium. We pressed a part of the plant which grew up from the seed and inserted this  
in the herbarium with the collector identified as *Veromessor pergandei*.

# # #

## CICINDELIDAE OF CALIFORNIA

INVESTIGATOR: William D. Sumlin III  
California State Polytechnic College

SUMMARY OF  
PROGRESS: Progress and findings for Death Valley segment unchanged from last  
years' report because no beetles were collected due to foul weather.

RECOMMENDATIONS: Impossible to predict future course of project at present due to current  
fuel shortage.

## GEOLOGIC MAPPING OF THE MARBLE CANYON QUADRANGLE

INVESTIGATOR: Edward A. Johnson  
University of the Pacific

SUMMARY OF PROGRESS: During the summer of 1973 approximately 25 field days were spent in detailed mapping between 27 May and 1 July. The area covered extended from Harris Hill to just east of Sand flat. A base camp was established at Hunter Cabin and access to the mapped area was by various secondary mine roads.

SIGNIFICANT FINDINGS: The structure of the upper and lower plates of the Marble Canyon thrust fault continues to unfold with this continued mapping. The actual thrust contact was traced to within one-half mile of the known position in the eastern part of the quadrangle.

RECOMMENDATIONS: Plans for the summer of 1974 are for continued mapping in the central part of the quadrangle. Objectives are to connect the east and west portion of the Marble Canyon thrust fault and to finish up all but the extreme north end of the quadrangle.

# # #

## FEEDING HABITS OF DESERT ANTS

INVESTIGATOR: George C. Wheeler  
University of Nevada, Reno

SUMMARY OF PROGRESS: Our first visit for this year was 22-28 February. We made one of our periodic surveys of our 10-acre plot near Grapevine Ranger Station. We counted 54 active nests on the plot. Of these, 41 were present when we made our first survey in 1968. Five more were counted in 1969 and 3 more since 1970.

Last spring, Steven Rissing, a junior biology major at the University of Indiana, wrote to Dr. West stating that he would like to get some field experience in the desert. Rissing proved to be an enthusiastic and capable field researcher. His problem was a field study of the behavior of the black desert harvesting ant (*Veromessor pergandei*). In June he and Dr. West poured a gallon of liquid plastic into a nest opening. This was allowed to harden 2 days and then Rissing excavated it with the greatest care. The remainder of his time was devoted to all aspects of the behavior of this species, but concentrating on harvesting.

After leaving Death Valley, Rissing spent 6 weeks at the Laboratory of Desert Biology in Reno writing up his field notes, studying the seeds harvested by the ants, and reconstructing the cast of the interior of the nest. In this work he was supervised by Dr. Jeanette Wheeler.

The cast spread 98 inches horizontally from the remainder of the nest entrances; it went the depth of 41 inches. It took the gallon of plastic to fill this one portion of the nest. Seed chambers were near the surface and brood chambers lower.

A report is now being prepared based on the Wheelers' (1968-73) and Rissing's (May-June 1973) observations of *Veromessor pergandei*, a black desert harvester. It will concern feeding and nesting data.

We have estimated 2 years for this study, but that is meaningless. We have found

20 species of ants in the monument; 6 of these are harvesters. So the study is interminable. How long we continue it will depend upon (1) how long the monument staff wants us around; (2) how much time we can afford, (3) the gasoline supply; and (4) the rainfall.

# # #

### MORMON POINT AND COPPER CANYON TURTLEBACKS

INVESTIGATOR: James Otten  
Pennsylvania State University

SUMMARY OF REGIONAL mapping of area complete, some detailed mapping to be finished.  
PROGRESS: Significant corrections of the mapping by H. Drewes have been made. The diorite unit outlined by Drewes has been reinterpreted as Mesozoic in age rather than Pre Eocene. The metamorphic units can be subdivided into older schists and gneisses and younger metamorphosed Pahrump Group (?) rocks.

The complex of metamorphic rocks exposed in the central Black Mountains can be subdivided into a sequence of granitic to mafic gneisses and schists and a younger succession composed of marble and subordinate quartzite and schist. The complex has been intruded by a discordant body of diorite previously assigned as older Precambrian age. As the diorite is relatively unmetamorphosed, it may be Mesozoic or younger. If so, the carbonate-clastic sequence is best correlated with the Pahrump Group and the metamorphism related to the intrusion of the diorite. The sequence is lithologically similar to the lower part of the Pahrump Group. Pre-Pahrump units in the Death Valley area are almost carbonate free. The diorite was later intruded by granitic to monzonitic dikes and shallow plutons largely or wholly of Tertiary age. The dikes, associated largely with the latest plutons, show various orientations. Within the metamorphic complex they are subvertical and strike northeast, compatible with northwest crustal extension. Dikes emanating from these later plutons and intruding the surrounding diorite and earlier Tertiary plutons are commonly subhorizontal.

Folding of the metamorphic rocks to produce the anticlines that coincide with the well-known turtleback surfaces predates the Tertiary plutons and probably the diorite pluton. Innumerable northeast trending normal faults postdate the youngest of the plutons which are probably late Miocene in age. Movement on the turtleback faults in the central Black Mountains probably began no earlier than the early Pliocene.

It is anticipated that the presently planned course will complete the project as originally outlined.

# # #

### SEDIMENTOLOGY OF THE ZABRISKIE QUARTZITE

INVESTIGATOR: John J. Barnes  
University of Illinois

SUMMARY OF The Zabriskie Quartzite of the southwestern Basin-and-Range Province  
PROGRESS: ranges in thickness from zero to 300 m. It contains paleotidal range sequences, "B-C" sequences, variable cross-bed orientation, *Scolithus* burrows, *Monocraterion* escape structures, mud-cracks, and washout structures. The

Zabriskie intertongues with the Harkless Formation which consists of interbedded mudstone, siltstone, and sandstone. Sedimentary features in the Harkless include paleotidal range sequences, flaser bedding, "B-C" sequences, mud-cracks, and *Monocraterion* escape structures. The Harkless and Zabriskie are interpreted to have been deposited on both intertidal flats and shallow subtidal sand bodies.

The facies change from the sandy Zabriskie Quartzite to the muddy Harkless Formation has been traditionally interpreted as one of deepening water and increasing distance from shore. However, abundant exposure criteria and shallow water sedimentary structures indicate the two formations are similar in environment with textural variation due to sediment transport history. Such a model coincides with Holocene tidal models where mud deposition occurs in embayed estuaries and high tidal flats. Sandstone-mudstone intertongues elsewhere may represent a similar history.

# # #

### PHYSIOLOGICAL ECOLOGY OF RODENTS IN DEATH VALLEY

INVESTIGATOR: Daniel S. Fertig  
California State University

SUMMARY OF PROGRESS: John Ledger and I spent one weekend in August at DVNM. Live trapping yielded only 2 animals: *Neotoma lepida* and *Amnospermophilus leucurus*. One *Lepus californicus* and several other *A. leucurus* were seen in the study area.

SIGNIFICANT FINDINGS: Urine analysis (osmotic and chloride concentrations) indicated that *N. lepida* was well hydrated at the time of capture (around midnight).

RECOMMENDATIONS: Reluctantly, we have decided to terminate our project at DVNM for the following reasons:

1. During the summer, the ambient temperatures at night were not what we expected, e.g., 110-115°F temperatures I encountered in August 1970.
2. The trapping yield was inadequate to provide us with a statistically significant sample size of species of interest to us, *Peromyscus crinitus* and *Dipodomys merriami*, considering our fiscal and logistical limitations.

We appreciate the cooperation we received from the staff at DVNM.

# # #

### ANALYSIS OF SEDIMENTS: ALLUVIAL FANS

INVESTIGATOR: Bernard R. Maynard

SUMMARY OF PROGRESS: Five alluvial fans were profiled and sampled along the east side of Death Valley in August 1973 with samples taken from the Apex, Mid-point, and Toe.

Analysis of sediments will be compared to 45 other alluvial fans throughout the southwestern United States.

Analysis of sediments is now underway.

## INSECT DISTRIBUTION; RELICT POPULATIONS

INVESTIGATOR: Derham D. Giuliani  
California Academy of Sciences, S.F.

SUMMARY OF Most of my available time was used examining similar habitats outside  
PROGRESS: the monument. Of the four important seasonal periods on the inland  
sand dunes, I learned only a little concerning the January-February and  
March-May periods at the Stovepipe Wells dunes.

All beetles found at the dunes, in the form of live as well as pieces of dead specimens, were species which live in the desert surrounding the dunes. None of the specialized dune species which occur at other dunes outside the monument could be located. This includes the beetle *Eusattus muricatus* LeC which was found at every one of over two dozen other dunes examined in California and Nevada. Either the dune is very recent or these insects died off from some cause in the past. In either case no recent corridor of access has occurred from any of four possible directions for them to become established or re-established there.

The monument's dunes must be searched in great detail throughout the year in order to learn its relationship, if any, to the other dune areas. Cost of getting to and from the area will probably limit my progress with this project.

# # #

## WOOD CANYON, STERLING, AND ZABRISKIE FORMATIONS

INVESTIGATOR: Paul E. Diehl  
Pennsylvania State University

SUMMARY OF Work on measurement of stratigraphic sections and paleocurrent indicators  
PROGRESS: for interpreting paleoenvironments of deposition of the sediments of the  
Precambrian?-Cambrian Wood Canyon Formation began in late October 1972  
in the Death Valley National Monument and surrounding area. Field work continued until  
March 1973. During that time three stratigraphic sections were measured in great detail  
(bed-by-bed) and four other sections were measured in lesser detail. Approximately  
1750 paleocurrent features include cross-laminations, flute casts, parting lineations,  
and form ripples. Stratigraphic sections thus far investigated are located in the  
Southern Nopah Mountains, Resting Springs Mountains, Tucki Mountain in the vicinity of  
Mosaic Canyon, Panamint Mountains in Trail Canyon, S. Salt Spring Hills, McClain Peak, and  
the Kingston Range. Directional features were measured only (section not measured) in  
Titanothera Canyon.

Field work of much the same nature will again be carried out during March and April  
1974. That field work should complete the field investigation necessary to describe  
in detail the sediments of the Wood Canyon Formation and to draw some regional  
conclusions as to their origin, the environments of deposition, and their tectonic  
implications. During that time measurements will be made in the Silurian Hills, Winters  
Peak, southern Panamint Mountains, Daylight Pass area, and in the Spring Mountains,  
Nevada.

## CORRELATION OF FAN GRAVELS AND PLAYA DEPOSITS WITH RADAR IMAGERY

INVESTIGATORS: Graydon L. Berlin) U.S. Geological Survey, Flagstaff, Arizona  
Gerald G. Schaber)

SUMMARY OF G. L. Berlin and G. G. Schaber during the past 3 years have spent  
PROGRESS: approximately one month in Death Valley, California, field evaluating  
25-cm wavelength side-looking radar images obtained by Jet Propulsion  
Laboratory personnel in 1969 and 1970. These overflights served as calibration tests  
for a prototype radar system designed to obtain high resolution image and profile data  
from orbit around the cloud covered planet Venus. The early 1980s Venus mission is  
currently in the planning stages by NASA. The Death Valley area was chosen as the radar  
system calibration site due to the nearly total lack of flowering vegetation in the  
valley floor and the extremely low (1.65 inches per year) precipitation.

The carbonate and sulfate salt flats of the valley floor and large alluvial fans  
at the base of the valley walls were found to produce sensitive radar backscatter  
differences that were correlated with variations in surface roughness. Distinct low  
radar backscatter bands (not differentiated on published geologic maps) along the base  
of all alluvial fans were found to be caused by a loose sandy facies with reduced gravel  
and boulder populations. Elevated, older gravel terrace remnants show on the radar  
images as reduced backscatter regions owing to their flat desert pavement morphology  
with all boulders being well fitted onto a flat surface with desert varnish coatings of  
iron and manganese. The younger Pleistocene fan gravels that cut the older fan gravels  
are moderately bright radar backscatterers with rough, irregular surfaces composed of  
many 20 to 30 cm-sized boulders lying well above the average surface level.

Flood plain deposits in the valley floor are characterized by very low radar  
backscatter and are extremely smooth and flat with surface roughness on the scale of one  
centimeter. The flood plain material which is of recent age has a thin salt crust which  
in turn is underlain by very fine sands and silt. The Devil's Golf Course, a very rough  
(0.5 m scale roughness) massive halite deposit, gave the brightest radar backscatter of  
any geologic unit in the valley floor.

A correlation of radar backscatter power and material coherence was also observed.  
Loose, uncemented sandy gravels appear to give a lower backscatter than material of  
similar surface roughness cemented by carbonate and sulfate salts.

Samples and photographic data from the valley are currently being analyzed and  
publication of this investigation will occur in 1974 (Schaber, Berlin, and Brown). This  
publication will represent the second in a series; the first investigation centered on  
an area just north of Flagstaff, Arizona (Schaber, G. G., and W. E. Brown. 1972. Long-  
Wavelength Radar Images of Northern Arizona-A Geologic Evaluation; Geological Survey  
Research; U.S. Geological Survey Professional Paper 800-B, pages B175-B181).

# # #

### VEROMBESSOR ANTS, OTHER DEATH VALLEY WORK

INVESTIGATOR: Peter L. Comanor  
University of Nevada

SUMMARY OF One project specifically is not the only work. Vegetation analysis is an  
PROGRESS: ongoing project, done each spring. Ant work (in the sense of a finished  
product) has been completed, although additional work is planned as time

permits. Study of desert plants continues; a project on *Yucca brevifolia* ecology will be initiated at the north end of the monument this coming spring.

Behavioral ecology of the harvester ant has been studied, and behavior in relation to environmental variables as well as impact on the environment (re., food source) has resulted in completed work.

Data on pattern of desert plants have been accumulated since 1967. Significance awaits final analysis.

Note that much of this work is associated with its educational value, since students in various courses in the Biology Department at UNR are involved in studying the ecology of the monument on these trips.

RECOMMENDATIONS: I would recommend continued liaison of NPS personnel/facilities with academic/university personnel. I further recommend continued support (if only through use of your facilities) for non-Federal researchers who will, through their research, contribute to an understanding of the ecology of the areas under your jurisdiction.

# # #

#### GEOLOGICAL INVESTIGATION OF THE WINGATE WASH MINE IN THE VICINITY OF USGS BENCHMARK 480

INVESTIGATOR: Ronald J. Grabyan  
University of Southern California

SUMMARY OF PROGRESS: Field work should be completed by 1 January 1974, but additional field exploration may be necessary. Geophysical (magnetic, gravity, and seismic) surveys are complete. Geochemical investigations are near completion. Petrographic analysis and statistical analysis of data are still in incipient stages. A final report should be finished by 1 June 1974. If you should require or would like a copy of my thesis, please contact me.

Economic possibilities are difficult to evaluate at this time. When all the data are collated, I will be in a position to make recommendations. The data so far are promising.

The investigations are going according to plans to date.

# # #

#### BEHAVIORAL CYCLES IN DESERT PUPFISHES

INVESTIGATOR: Robert E. Brown, Jr.  
California State University

SUMMARY OF PROGRESS: Research at Salt Creek is terminated. Documented downstream drift of young during flooding February 1969 and 1973. Summer death due to desiccation and loss of demoregulatory control in isolation pools. In October 1972 McLean Spring (2 pools and long "L" shaped pool) constituted only permanent H<sub>2</sub>O and recognizing population source. Virtually no upstream (between pool) movement (June 1970-71). During drying of creek fish remain in pools to which they have immigrated during spring.

MONOGRAPHIC STUDY OF *BOERHAVIA*, *ASTRAGALUS*, ETC.

INVESTIGATOR: Richard Spellenberg  
New Mexico State University

SUMMARY OF PROGRESS: Several projects are involved: that on *Astragalus* is about 90% complete; that on the Southwestern Flora about 5% or so; while that on *Boerhavia* and *Anulocaulis* is about 25%.

The chromosome number for *Astragalus layneae* was determined to be  $2n = 44$ , unusual in the genus in that it represents a tetraploid. Project is continuing throughout the western United States.

Collections were obtained of *Boerhavia annulatus*, a species sometimes placed in *Anulocaulis*. These were excellent collections, the plants in excellent condition probably due to the good spring of 1973. Collections included pressed material, chromosomal material, and seeds for growth of experimental plants. I have discovered that *B. annulatus* has  $2n = 48$  chromosomes which allies it with *Anulocaulis* on the Chihuahuan Desert and not with *Boerhavia* ( $2n = 52$  to date).

# # #

DETERMINATION OF TECTONIC STRAIN, DEATH VALLEY

INVESTIGATORS: Frederick Keller )  
Arthur G. Sylvester) University of California, Santa Barbara  
Richard P. Keller )

SUMMARY OF PROGRESS: During March 1973, four level lines established by C. T. Foster in 1970 across faults in Death Valley, and the level line established by F. B. Keller in 1972 across the Furnace Creek fault in Fish Lake Valley were resurveyed. Leveling data of line 70 show a continuous westward tilting along the fault at the Hanaupah Escarpment on the southern side of Death Valley, which may represent a small western component of the south-southwestward tilt produced by a growing structural high across the valley floor to the north, mentioned by Greene (1966). A sharp difference in elevation changes across the fault scarp may also indicate vertical fault creep since the last survey of F. B. Keller in March 1972. In addition, line 130, near Triangle Spring, is experiencing a consistent southwestward tilt along the Furnace Creek fault. An additional level line was established across an alluvial fan extending from Titus Canyon, 7 miles northwest of Triangle Spring, and will serve as a temporary control level line. This level line will be extended later across the Furnace Creek fault and an accompanying strain figure established so that data obtained from this line can be compared to that of line 130. A permanent control level line will be established on a geologically stable fan on the opposite side of the valley in order to monitor the level of geodetic noise expressed in the survey data. More strain figures should accompany established level lines for the purpose of determining horizontal tectonic strain accumulation along the Furnace Creek fault zone.

Dr. Sylvester has been in Bergen, Norway, working in the University Education Abroad program since September 1972, and should return by September 1974. This summary has been provided by the project's current researcher who is also continuing the project in 1974. Further research will be necessary in order to determine a more accurate picture of tectonic strain accumulation in the Death Valley region, since this phenomena operates on a geologic time scale rather than an "animal" time scale.

References:

- Greene, G. W. 1966. Tiltmeter measurements. Pages A112-A114 *in* C. B. Hunt, and D. R. Mabey, Stratigraphy and Structure Death Valley, California. U.S. Geological Survey Professional Paper 494A.
- Foster, C. T., Jr. 1971. Geodetic monitoring of tectonic strain in Death Valley, California, from September 1970 to August 1971. Unpublished President's Undergraduate Fellowship Report, Univ. Calif., Santa Barbara. 22 p.
- Keller, F. B. 1971. Determination of tectonic strain in Death Valley and Fish Lake Valley, California. Unpublished report to Arthur G. Sylvester, Univ. Calif., Santa Barbara. 21 p.
- \_\_\_\_\_. 1972. Tectonic strain determination in Death Valley and Fish Lake Valley, California. Unpublished President's Undergraduate Fellowship Report, Univ. Calif., Santa Barbara. 29 p.
- Keller, R. P. 1973. Determination of recent tectonic strain in Death Valley and Fish Lake Valley, California. Unpublished President's Undergraduate Fellowship Report, Univ. Calif., Santa Barbara. 31 p.

# # #

*PEROMYSCUS MANICULATUS*

INVESTIGATOR: Lee R. G. Snyder  
Stanford University

SUMMARY OF My Ph.D. dissertation project concerns genetic differentiation among  
PROGRESS: populations of deer mice along altitudinal gradients in eastern  
California. I need samples from the low elevations of Death Valley to  
compare with samples of populations at higher elevations in the Panamint and White  
mountain ranges. On a single collecting trip to Death Valley in March 1973, I was able  
to catch only *Peromyscus eremicus*, instead of *P. maniculatus* which I had hoped to collect.  
(The mice were trapped live and returned to their natural habitat.) Consequently I will  
probably apply for another collecting permit this spring and attempt once again to trap  
*P. maniculatus*.

# # #

ARCHEOCYATHID FAUNAS OF LOWER CAMBRIAN

INVESTIGATOR: Roland A. Gangloff  
University of California

SUMMARY OF I will submit a detailed summary of findings which directly relate to the  
PROGRESS: Daylight Pass area at the end of August 1974.

## BREEDING OF *CYPRINODON*

INVESTIGATOR: Alfred D. Castro  
California Academy of Sciences

SUMMARY OF PROGRESS: The breeding population of *Cyprinodon nevadensis nevadensis* is increasing. The purpose of this population is to insure an adequate number of mature individuals to keep Death Valley pupfish on display for the public. This portion of the project is complete.

The breeding population of *Cyprinodon salinus* is not a complete success. The population is maintaining itself but not in sufficient numbers for more than an occasional display. This project is still in progress.

The breeding population of *Cyprinodon milleri* was not established as intended. The only individuals found were 11 juvenile fish, approximately 12 mm TL. These fish did not survive to sexual maturity. They were found near an isolated spring on the West Side Jeep Trail where it runs at the base of Chloride Cliffs. The fish were found under a crust of dried mud which had a layer of water approximately 3 cm in depth.

# # #

## SPECIATION MECHANISMS IN BLISTER BEETLES

INVESTIGATOR: John D. Pinto  
University of California, Riverside

SUMMARY OF PROGRESS: Only a minor part of my total project is being carried out in Death Valley National Monument; most of this was completed last year. The monument is the only known area where one of the species of interest, *Epicauta magnomaculata* Martin, occurs. I collected this species in large numbers last April and was able to record host preferences, sexual and nonsexual behavior, and obtain first instar larvae. This species has proved to be very closely related to *E. ventralis* Werner which occurs to the north and at higher elevations. I am assuming that the Death Valley population was pinched off *E. ventralis* and speciated after one of the climatic shifts southward during Pleistocene times.

# # #

## SUMMARY OF DOCUMENTED EFFECTS OF BURROS ON DEATH VALLEY NATIONAL MONUMENT

INVESTIGATORS: Peter G. Sanchez) DEVA  
Larry A. May ) DSC

SUMMARY OF PROGRESS: The available literature on burro ecology and management was reviewed and summarized to assist in the documentation of burro population effects on the natural and aesthetic environments of Death Valley National Monument. This summary was included as a portion of the Description of the Environment in the wilderness environmental statement, and will be included in the Resources Management Plan's environmental statement.

MORTALITY OF DESERT HOLLY  
DEVA-N-5

INVESTIGATOR: Charles Douglas  
University of Nevada

SUMMARY OF PROGRESS: Jack Fisher is conducting controlled experiments on seedlings at University of California, Riverside. Plants are exposed to varying kinds and concentrations of pollutants in controlled environmental chambers. This phase of the study has been underway for only a few weeks. Study plots in Death Valley are monitored regularly for seedling survival, pollution damage, etc. Mr. Fisher is enrolled in a graduate program at U.C. Riverside, and will utilize this research for his Masters Thesis. Germination percentages of seeds from Death Valley plants have been very high. We were concerned that seedlings might be difficult to raise, but this is no longer a concern, and thus the research can proceed as planned.

# # #

BIGHORN ECOLOGY  
DEVA-N-10

INVESTIGATOR: Charles Douglas  
University of Nevada

SUMMARY OF PROGRESS: Due to the untimely death of Dr. Charles Hansen, the investigator was hired to fill the position vacancy in September 1973. The remainder of 1973 was spent becoming familiar with administrative concerns of the position, with the attendance of numerous meetings relevant to the position, and to research on bighorns. Considerable time was devoted to reviewing the literature and reading the files to determine what state the study was in. A waterhole count was made in September 1973 by VIP observers. A total of 78 sheep was recorded for 18 waterholes. Automatic movie cameras (super 8) that take one frame per specified time interval will be utilized later in 1974 to count animals at more inaccessible springs.

# # #

BURRO ACTIVITY EVALUATION  
DEVA-N-11

INVESTIGATOR: Charles Douglas  
University of Nevada

SUMMARY OF PROGRESS: Due to the untimely death of Dr. Charles Hansen, the investigator was hired to fill the position vacancy in September 1973. The remainder of 1973 was spent becoming familiar with the personnel and terrain of Death Valley. Several meetings were attended that relate to feral burro problems in the Southwest. Considerable time was spent in reviewing the literature on feral burros and in evaluating the status of the study to date. Two graduate students are assisting in burro studies in DEVA. One student is concerned with parasites and disease organisms of burros; the other is concerned with blood biochemistry and physiology. Both will be

involved in other aspects of the study, such as seasonal movements, food habits on a seasonal basis, reproduction, and interaction of burros and desert bighorn.

## DINOSAUR NATIONAL MONUMENT

### ECOLOGY AND SYSTEMATICS OF NATIVE COLORADO RIVER BASIN FISHES

INVESTIGATOR: Paul B. Holden  
Utah State University

SUMMARY OF PROGRESS: The project has been completed and findings have been reported in a dissertation. A copy has been sent to Dinosaur National Monument. The Green and Yampa rivers in Dinosaur National Monument are extremely important to the survival of endemic fishes in the Upper Colorado River basin.

## EVERGLADES NATIONAL PARK

### GEIGER TREE PROPAGATION

INVESTIGATORS: G. Jay Gogue )  
Dennis B. Fenn ) National Park Service Science Center

OBJECTIVES: The Geiger tree (*Cordia sebestena* L.) is a native ornamental which was once found throughout the Florida Keys. Over the years, the population of the Geiger tree has been greatly reduced, and currently there are no Geiger trees on the island at Fort Jefferson where they once grew and very few remain in Everglades National Park. There is no literature concerning the methods or procedures used in propagating the tree and there appears to be no commercial nurseries involved with increasing the population. The purpose of this research is to develop techniques for the propagation and reestablishment of the Geiger tree in south Florida.

METHODS: Hardwood cuttings were received from a plant material source in Puerto Rico in the late fall. The cuttings were trimmed to approximately 15 cm in length and treated with various root promoting compounds (Table 1). Next the cuttings were placed under intermittent mist with an atmospheric temperature of 23-27 C and a soil temperature of about 21 C.

Table 1. Various root-promoting compounds used in the initial hardwood study

Treatment number	Material	Concentration	Time of treatment
1	Aqueous Indolebutyric Acid	200 ppm	24 hours
2	Aqueous Indolebutyric Acid	4000 ppm	5 seconds
3	Powdered Indolebutyric Acid	5%	Coat Cutting Base
4	Aqueous Naphthaleneacetic Acid	200 ppm	24 hours
5	Aqueous Naphthaleneacetic Acid	4000 ppm	5 seconds

RESULTS: The results are not conclusive at this point, but the early work with the hardwood cuttings seems promising. Four weeks after treatment, it appears (Table 2) that the root-promoting materials have in all cases stimulated callus formation while the control cuttings have not generated callus. It is still too early to determine if or when root emergence would occur.

Table 2. Geiger tree propagation from hardwood cuttings

Treatment number	Callus formation	Root emergence
1	X	0
2	X	0
3	X	0
4	X	0
5	X	0
control	0	0

PLANS FOR 1974: Further asexual propagation techniques will be explored and in addition sexual propagation procedures will be initiated.

# # #

#### ENCROACHMENT OF EXOTIC PLANTS IN EVERGLADES NATIONAL PARK

INVESTIGATORS: G. Jay Gogue )  
 Clyde J. Hurst) National Park Service Science Center  
 Dennis B. Fenn)

OBJECTIVES: The purpose of this research is to determine the influence of exotics (*Schinus terebinthefolius* and *Casuarina equisetifolia*) on native plant populations. This involves first determining if native plants are affected by the exotics. Secondly, it must be determined how the exotics influence the natives--either by competitive or noncompetitive (allelopathic) or both type effects.

SUMMARY OF PROGRESS: The initial study was undertaken to indicate if there is a toxic material "given-off" by the exotic plants which retards or stops native plant growth. For example, rain drippings from *Schinus* have been implicated due to high concentrations of materials which reduce germination of native plants. Leaves from both *Schinus* and *Casuarina* were collected either fresh or as litter. Next, 100 g (FW) of the leaves were placed in 1000 ml of distilled water and the leaves received one of the following treatments: (1) rinsed for 1 minute; (2) soaked for 1 hour; or (3) chopped in a blender. Twenty-five milliliter of the leachate was then used to germinate *Bromus rigidus* which served as a bioassay plant and 48 hours later radicle length was recorded. Results of this study are expressed in Table 1.

Table 1. The effect of various leachate treatments on radicle length of *Bromus rigidus*

Exotic	Treatment	Radicle Length (mm)
<i>Schinus terebinthefolius</i>	One hour rinse	5.63
	One hour soak	5.10
	Blender	1.80
	Control	7.87
<i>Casuarina equisetifolia</i>	One hour rinse	5.67
	One hour soak	6.33
	Blender	4.60
	Control	7.74

# # #

#### EFFECTS OF MOTOR BOATS ON TURTLE GRASS BEDS IN EVERGLADES NATIONAL PARK (RBI)

INVESTIGATORS: Joseph C. Zieman ) University of Virginia  
 William P. Gregg, Jr.) DSC

SUMMARY OF PROGRESS: The study was commissioned to permit articulation of a management philosophy with respect to the use of motorboats in portions of Florida Bay where damage to turtle grass beds from this activity is believed by many to have adverse long-term ecological effects. However, even qualitative information on the ecological implications of this use is unavailable. Use of motorboats is a critical factor in preventing designation of wilderness in this area. Restrictions on such use may become feasible, and eventual wilderness designation more likely, if adverse ecological effects can be documented.

Dr. Zieman was requested to conduct a preliminary study of the effects of motorboats on the integrity of turtle grass beds. The study contains the following components:

- (1) Compilation of relevant existing aerial photography in areas within the portion of Florida Bay that is included within Everglades National Park. This photography should be sufficient to provide a long-term record of the physical appearance of selected locations.
- (2) Description of changes in the number of propellor cuts and other definable types of disturbance during the period of record.
- (3) Description of changes in the appearance of propellor cuts and other disturbance zones during the period of record, with particular emphasis on the determination of the longevity of such disturbance zones.
- (4) Interpretation of the results of the study in a brief report that indicates

probable short- and long-term ecological effects of motorboat use and other sources of disturbance on turtle grass beds and baybottom sediments in Florida Bay.

A draft of the study report was submitted to the National Park Service in January 1974 and is now being reviewed. As a result of on-site field inspection of motorboat ruts, a limited number of available aerial photographs at a scale suitable for interpretation, and a few laboratory analyses, Dr. Zieman concluded that the adverse effects of motorboat use on turtle grass beds are largely temporary. Although regrowth of turtle grass rhizomes into scarred areas is slow, recolonization typically occurs if the area is not substantially disturbed for several years. Ruts in areas subject to heavy motorboat use often are not recolonized because of frequent disturbance, but these appear to be the exception rather than the rule. Much of the existing disturbance apparently could be controlled within acceptable limits by emplacing markers in strategic locations to limit use of motorboats in areas where such use is inappropriate. The preclusion of motorboats from most of Florida Bay cannot be justified on the basis of ecological damage to turtle grass beds, which apparently are able to tolerate existing levels of motorboat use without irreversible damage.

# # #

#### SEA TURTLE ROOKERY STUDY EVER-N-7

INVESTIGATOR: Gary E. Davis  
National Park Service

OBJECTIVES: The objectives of this study are to determine the number of turtles using the rookeries each season, understand the relationship of the rookeries to other major elements of the ecological system of which it is a part, and suggest management action that will perpetuate the entire ecological system.

METHODS: Aerial surveys of all park turtle rookeries and complimentary boat patrols at Cape Sable were used to estimate total nesting activity. Tagging and recapture efforts determined the number of nests each turtle builds. Beach surveys established the percentage of non-nesting emergences. A raccoon elimination program quantified the relationship between the turtle rookery and the raccoons.

RESULTS AND DISCUSSION: Ten years of observation and study were completed on the sea turtle rookeries of Everglades National Park in 1973. In that time we have seen a twofold increase in the nesting activity of loggerhead turtles, *Caretta caretta*, at the Cape Sable Rookery, but whether this represents a corresponding increase in the nesting population is unclear. The resident raccoon, *Procyon lotor marinus*, population at Cape Sable utilized 75-85% of the turtle eggs deposited on the beach. There is no evidence to suggest that this is an abnormal relationship between the raccoons and turtles. Three factors may have combined to permit the increased usage of the Cape Sable beaches by loggerhead turtles. Development of real estate and highway projects on nearby rookeries may have driven mature turtles to the wilderness beaches at Cape Sable (this same response to harassment occurred with the loggerhead turtles at Jekyll Island, Georgia, in 1960).

A sharp decline in nesting activity has occurred on the rookery at Highland Beach, which is adjacent to Cape Sable. This decline is due presumably to the invasion of Australian pines, *Casuarina* spp., which began crowding out natural beach vegetation following a hurricane in 1960. The shallow, widespread, root systems of these exotic trees makes it very difficult for a turtle to dig a satisfactory nest, thus rendering this once very productive sea turtle rookery nearly useless. The turtles historically using Highland Beach may have shifted to the closest available area, Cape Sable. The third factor is the release from hunting pressure that resulted from the establishment

of Everglades National Park. As protection of the natural resources of the new park began to become effective in the early 1950s, turtle turning at the Cape Sable Rookery decreased. Since we are concerned here with an increase of about 100 long-lived, nesting turtles that required some 10-12 years to mature, even the elimination of a small harvest could produce much of the increased activity we see today. Management of the Cape Sable Rookery should continue to emphasize preservation of its wilderness character.

PLANS FOR 1974: Continued monitoring of nesting at all park rookeries and tagging at the Cape Sable Rookery.

# # #

## SOUTH FLORIDA BIRDS EVER-N-8

INVESTIGATOR: William B. Robertson

SUMMARY OF PROGRESS: This project was originally designed to produce: (1) a definitive, technical account of the history, distribution, and status of bird life in southern Florida; and (2) good, popularly written accounts of the birds of Everglades National Park and Fort Jefferson National Monument for use by park visitors. Initial work determined that adequate realization of item 1 above would require at least 3-6 months of detached work in museums and other major data repositories (viz., Bird Banding Laboratory, BSWF, Patuxent, Md.) because very large amounts of information available in these places have never been assimilated into the published record of Florida birds. Because it was the investigator's firm opinion that item 2 should not proceed except from a sound technical basis, specific, detailed requests, including budget estimates, were first presented circa 1964 to cover necessary work at museums and other centers. Similar requests have been presented periodically since that time. To this date, it has not been possible to fund such work nor even to obtain a comment as to the propriety of using NPS official time and funds in such work. Consequently, the Service's premier bird park still has no bird book and, at the current rate of progress, it never will have one.

Despite the blunting of its original purpose, it was deemed useful to retain project EVER-N-8 to cover work devoted to (1) maintaining files of current bird records and library research pursuant to the original aim of the project; (2) short-term, one-shot ornithological researches of the investigator; and (3) other professional work in ornithology, especially refereeing and reviewing manuscripts.

Only relatively minor amounts of time were devoted to this project during the report period. As usual in recent years, project record files received little attention and are in poor shape. Principal accomplishments in the report period were: (1) publication of three short papers all in *Florida Field Naturalist*. Two of these are accounts of specific bird records at Fort Jefferson National Monument, the other is an editorial on the condition of the historical record of bird occurrence in Florida which expands upon some comments above. (2) Review and comment on manuscripts of some 45 papers, mostly dealing with Florida birds. Of these, approximately 15 were manuscripts sent to me for refereeing by editors of national scientific journals; about 25 were bird occurrence notes or brief papers submitted to *Florida Field Naturalist*; and the remainder were manuscripts sent privately by colleagues for comment. (3) Preparation of about 35 abstracts published as initialled contributions in the recent literature section of *The Auk*. (4) Activities as president of the new Florida Ornithological Society, including participation in planning and operation of meetings at St. Petersburg in April and Vero Beach in October and work on *Florida Field Naturalist* of which the first two numbers are now in print. (5) Helping plan and participating in the conference on Rare and Endangered Plants and Animals of Florida held in the Ocala National Forest in November. Conference work is expected to lead to a report which should have value

for land planners and state natural resources agencies. (6) Preliminary work accomplished toward a revised checklist of birds of Fort Jefferson National Monument for distribution to visitors.

PROSPECT: In CY 1973, as for a number of years past, EVER-N-8 involved a variety of activities all generally related to the bird life of the NPS areas in southern Florida. Individual activities are mostly short-term, but the project as now conceived has no completion date. It may be that many of the activities covered should not be construed as within the project format. If so, I should be so advised.

The project as it was originally conceived still needs to be done. The basic project need at this point is for a clear, authoritative decision as to whether park-based NPS research scientists may or may not appropriately undertake funded work away from their assigned areas in museums, etc. If not, the investigator would seek funds elsewhere in NPS or outside NPS, but, first, the matter seems to need a park-level decision.

Because bird life of Fort Jefferson National Monument presents fewer problems involving unrecorded data in museums (and, hopefully, many of these can be dealt with by correspondence), it is proposed to concentrate main-thrust activities of the project in CY 1974 on producing an authoritative list of Fort Jefferson National Monument birds. Completion of this job is estimated to require 60 days work of the principal investigator (30 days field, 30 days record analysis and writing) and 45 days technician support (library work and record compilation).

# # #

#### BALD EAGLE STUDIES EVER-N-9A

INVESTIGATOR: William B. Robertson, Jr.  
National Park Service

SUMMARY OF PROGRESS: This project was initiated because (1) disclosure of the effects of hard pesticides had caused intense concern about the survival of the Bald Eagle; and (2) little accurate information was available about the breeding population of Bald Eagles in the park. Project aims were to determine how many Bald Eagles nested in the park and what sort of nesting success they had. Work on the project has disclosed that the park harbors a successfully reproducing population that is probably the most important remnant of the species in the contiguous United States.

Aerial observation of nesting activities continued as in previous years. Records for the 1972-73 nesting year are shown below along with the mean and range of various values for the entire study.

	<u>1972-73</u>		1960-61 thru 1971-72
		<u>Mean</u>	<u>Range</u>
No. active territories	54	52.6	49-55
No. territories producing young	22	27.0	20-32
Percentage producing young	40.7%	51.3%	37.0%-60.8%
No. young produced	32	36.5	29-42
No. young per active territory	0.59	0.69	0.57-0.82
No. young per successful territory	1.45	1.44	1.25-1.60

In addition to the routine nesting survey the following project activities may be reported: (1) in June after nesting was completed, food remains (yet to be sorted and identified) were collected from 18 nests in Florida Bay, (2) a paper comparing productivity of the park population with other U.S. Bald Eagle populations was published.

PROSPECT: Several times before I have outlined the basic dilemma of this project to no apparent avail. I guess all I can do is try again to get the story across. The ABC's of the matter are as follows:

- (1) Because of the interest that attaches to the Bald Eagle and the great importance of the population in Everglades, the park clearly is obligated to keep close track of its eagles and their nesting success.
- (2) Project EVER-N-9 has kept track for some 13 years.
- (3) The job is now largely routine. It yields little new information of consequence, yet it claims substantial time as well as the lion's share of my research funds. As a result, progress to new research efforts and writing up results of the eagle study itself are significantly hindered.

In short, I am compelled to use scarce research funds and scarcer research time to maintain a routine wildlife monitoring effort that some years since should have ceased to be primarily a research responsibility. I suggest that the park bears a strong obligation quite apart from its research function to maintain current knowledge of the population status of major species, and particularly so where research has made adequate monitoring techniques available. I suggest again the advisability of a serious administrative search into means of staffing and funding wildlife census work because the problem will surely get worse as research studies of other species (Spiny Lobster, Wood Stork, Loggerhead Turtle, etc.) reach a routine monitoring stage.

Progress with the paper on the breeding biology of Everglades National Park Bald Eagles which will constitute the completion report on this phase of EVER-N-9 was minimal in CY 1973, limited to a small amount of library work and data analysis. In the continuing absence of technician support, most of the time available for EVER-N-9 was necessarily devoted to routine data collection. I estimate that completion of this writing job will require 90 days work of the investigator and approximately 30 days technician support.

Once the above writing job is completed (or concurrently should technician help be available) the logical next phase of EVER-N-9 would involve (1) intensive study of individual Bald Eagle territories of known reproductive history; and (2) study of roosts of subadult Bald Eagles.

# # #

#### FLORIDA BAY OSPREY STUDY EVER-N-9E

INVESTIGATOR: John C. Ogden  
National Park Service

SUMMARY OF PROGRESS: The 6th year of intensive study of 55 pairs of Ospreys nesting on three keys in western Florida Bay was completed during the spring of 1973. This study has effectively established the Osprey as an indicator species for monitoring future status of other fish-eating vertebrates in Florida Bay (example: low Osprey productivity in 1973 correlated with similar low productivity by Brown Pelicans and Cormorants). Accurate information is now at hand on food habits, seasonal movements, population dynamics, pesticide and polychlorinated biphenol levels in Ospreys, and year to year fluctuations in nesting success. It is anticipated that the up-coming 7th year will be the last year of intensive study of these Ospreys, and that these birds will be available for the indicator role should environmental

contamination or increased human activity have adverse effect on Florida Bay fish-eating vertebrates.

# # #

#### WOOD STORK STUDIES EVER-N-12

INVESTIGATOR: John C. Ogden  
National Park Service

SUMMARY OF PROGRESS: The major achievement during 1973 was the completion of a manuscript by James Kushlan, John Ogden, and Aaron Higer on the relationship between past years of stork nesting, the 1966-72 USGS quantitative fish sampling results, and water levels in the Shark Slough for these same years. This analysis provided a much improved understanding of reasons for the frequent nesting failures by storks and other wading birds and resulted in a proposal for experimental management of water distribution in the Shark Slough during the 1973-74 winter nesting season. This experiment is designed to determine whether increased water management can stimulate earlier rookery formation by storks, a condition we feel is needed for improved nesting results.

The situation with storks is considered so critical that time was spent during 1973 in rearing nestling storks in captivity to determine the procedures necessary to successfully fledge into the wild young that are abandoned in rookeries. This sort of technique with large numbers of young would admittedly represent a desperate last-gap effort only intended to delay stork decline until some more permanent solution becomes available. Studies of Wood Storks understandably will need to continue for several more years, propably at a rate greater than at present, if these birds are to survive as a breeding species in the everglades.

# # #

#### CONTROL OF EXOTIC PLANTS IN EVERGLADES NATIONAL PARK EVER-N-18

INVESTIGATOR: Larry Bancroft  
National Park Service

SUMMARY OF PROGRESS: Burning and the use of full strength 2.4D (49.8% AI) were found to be an effective method of killing Australian pine. A 75-80% kill is achieved after one treatment. A control program was started during 1973. To date, more than 24,000 Australian pine have been killed.

Research during 1974 will concentrate on determining the best method to kill Brazilian holly. Cacodylic acid appears promising but more testing will be necessary.

Melaleuca has been killed with 2-4D, but more tests will be required to find the best method to kill it.

Mapping of other exotics, especially *Colubrina*, will be undertaken during the year.

SMALL MAMMAL POPULATIONS OF THE EVERGLADES  
EVER-N-22

INVESTIGATOR: Walter Sheppe  
University of Akron

SUMMARY OF PROGRESS: Further work on this project has been postponed indefinitely. Please inactivate my file until further notice.

# # #

BREEDING BIOLOGY AND ECOLOGY OF THE WHITE-DOWNED PIGEON  
EVER-N-23

INVESTIGATORS: Alexander Sprunt, IV)  
Richard T. Paul ) National Audubon Society

SUMMARY OF PROGRESS: This is a part of a long-term study of the species both in Florida Bay and in the Bahamas. Studies in the park have been concerned with productivity and other aspects of breeding biology. Some banding has been done and will probably be continued as time and other considerations permit.

# # #

FLORIDA BAY CROCODILE STUDY  
EVER-N-26

INVESTIGATOR: John C. Ogden  
National Park Service

SUMMARY OF PROGRESS: The major effort in the field during calendar year 1973 was to initiate radio tracking of hatchling and adult crocodiles as a means of quantifying habitat requirements and seasonal movements by these age classes. No adults were successfully tracked, but important preliminary information on dispersal, survival, and habitat of hatchlings was obtained. We continued from previous summers our efforts to determine factors affecting nesting success at all known sites, searched additional parts of the nesting range not previously surveyed, and again used automatic cameras to gather nest behavior data. A paper is now in preparation describing the habitat, range, and status of the south Florida crocodiles, with management recommendations for improving nesting success for those in Florida Bay. Another two summers of radio tracking still is needed, however, for sufficient habitat quantification, and to determine the extent of seasonal movements by Florida Bay crocodiles to areas outside park boundaries.

CAPE SABLE SPARROW (*AMMOSPIZA MARITIMA MIRABILIS*),  
DISTRIBUTION, ECOLOGY, AND MANAGEMENT  
EVER-N-28

INVESTIGATOR: Harold W. Werner

SUMMARY OF PROGRESS: Several colonies were surveyed. Taylor Slough colony was found to occupy approximately 3000 acres of wire grass prairie. Areas in the center of the slough and areas where the prairie was invaded by brush were not occupied. An additional colony was located on Fox Lake Prairie occupying approximately 5-10 acres of *Spartina* broken up by numerous ponds and creeks.

In the Taylor Slough colony three nests were located; one was in our area that was burned the year before. Activities centered principally on nest studies and included preliminary work on growth and development, nesting and nestling behavior, nest construction, activity periods, environmental responses, vocalization, etc. Adults and fledglings were banded and color-marked for future studies.

# # #

SEDIMENTARY STRUCTURES OF LAGOONAL CARBONATE MUDS, FLORIDA BAY  
EVER-N-32

INVESTIGATORS: Robert N. Ginsburg) University of Miami  
Edward C. Zins )

SUMMARY OF PROGRESS: The mud bands in Eastern Florida Bay are now seen to be physical accumulations rather than the result of grass trapping. The principal source of lime mud is believed to be the lightly calcified Codiacean algae and serpulid worm tubes that inhabit the deeper, open water sounds or lakes. Wave action during winter storms suspends mud produced in the lakes and moves it to the banks.

Coring through the mud banks has established that they did not originate when sea level first flooded the solid limestone floor of Florida Bay some 4000 years ago. Instead, there was a significant lag, some 2000 years, before sufficient mud was generated to nourish the banks.

Several of the islands in Eastern Florida Bay show both on the surface and in the subsurface clear indications of expansion to the east and erosion on the west. This asymmetric development is a result of winter storms that produce eroding waves on west-facing shores, while at the same time mud accumulates on the shielded lee sides.

Reports of these findings and the sequence of sedimentary structures and textures are being prepared for journal publication. The research will continue during the coming year, with the main objective of completing the history of sedimentation and documenting its features.

SHARK SLOUGH ALLIGATOR STUDY  
EVER-N-34

INVESTIGATOR: John C. Ogden  
National Park Service

SUMMARY OF PROGRESS: The Shark Slough alligator study was close to being on the inactive list for 1973, due to increased commitments by the principal investigator to the expanded crocodile study. Aerial surveys and interviews with rangers did provide nonquantitative information on timing and extent of nestings, and on nesting success. Monthly surveys of numbers and size of alligators in L-67 canal were also maintained throughout the year, in an effort to measure long-range alligator population trends, and to understand relationships between changing surface water levels and movements of different age-classes of alligators. Much more time needs to be devoted to this study for several years before alligator distribution, nest-site requirements, and alligator-water relationships are fully understood.

# # #

FLORIDA BAY FISHERIES RESEARCH PROJECT  
EVER-N-36

INVESTIGATOR: Thomas W. Schmidt  
National Park Service

OBJECTIVES: The objectives of this project are:

1. To develop and conduct an ecological survey in Florida Bay in order to describe most effectively the community of ichthyofauna and invertebrates inhabiting a particular area and derive a basic understanding of spatial distribution, determine how sport and commercial fishery populations change, and quantify as well as possible the numbers and weights of the individuals per unit area.
2. Baseline ecological data will be collected and analyzed through seasonal, relative, and absolute abundance, life history aspects, and trophic relationships of the biota within Florida Bay.
3. To establish a park reference collection from fish and invertebrate specimens taken during the regular sampling schedule.
4. To determine the relative and absolute abundance of fish and invertebrate species by their representative benthic habitats.
5. Results from this survey will be used to assist in the evaluation of sport and commercial fisheries resource management programs within the Florida Bay portion of Everglades National Park.

METHODS: During the months of May through November 1973, there were a total of 70 regular fish collections, consisting of 56 15.2 m seine hauls and 14 4.2 m semi-balloon otter trawl tows. Ideally, the monthly standard-unit-of-effort was composed of 16 collections represented by single hauls at each of eight seine stations and duplicate tows at four otter trawl stations.

Unfortunately, due to equipment inconveniences, monthly otter trawl sampling did not begin until October 1973. Seine stations were located at Joe Kemp Key, Buttonwood Canal, East Cape, Murray, Clive, Man-o-War, Sandy, and Plam keys, while trawl tows were made in Conchie Channel, Joe Kemp Channel, Palm and Rabbit Key basins. Data on fishes and macro-invertebrates were also obtained during exploratory surveys in the study area, including East Cape Canal and Curlew Key. In addition, sport fishery data

were utilized from creel census interviews, conducted at Flamingo. These random collections were used to supplement both ecological information and the list of species from the study area.

**RESULTS AND DISCUSSION:** Preliminary results of baseline ecological data in northwestern Florida Bay (Area I).

A total of 56,479 individuals distributed among 86 species and 39 families were collected, then sorted, identified, counted, measured, and weighed in the laboratory research trailer. They were taken by seining and trawling from the regular monthly collection of May through November 1973. An additional 14 species were collected from exploratory investigations or reported from census surveys in the study area.

The five most abundant fish species in decreasing order of abundance were striped anchovy (*Anchoa hepsetus*), bay anchovy (*Anchoa mitchilli*), gold-spotted topminnow (*Floridichthys carpio*), silver jenny (*Eucinostomus gula*), and rainwater killifish (*Lucania parva*). These forage fishes are major food items of many of the sportfishes found in park marine waters including speckled trout (*Cynoscion nebulosus*), tarpon (*Megalops atlantica*), ladyfish (*Elops saurus*), barracuda (*Sphyræna barracuda*), snook (*Centropomus undecimalis*), and mackerel (*Scombomorus maculatus*). In addition, numerous wading birds including the Wood Stork (*Myeteria americana*), Roseate Spoonbill (*Ajaja ajaja*), Great Blue Heron (*Ardea herodias*), and American Egret (*Casmerodius albus*) were observed apparently feeding in habitats dominated by three of the five most abundant fishes (excluding anchovies) collected during the preliminary and regular monthly sampling schedule.

The striped anchovy was the dominant fish species in the bay accounting for 32% of the total catch. The other above species represented 56% of the total catch.

The numerical distribution of the dominant fish families as a percent of the monthly catch is shown in Table 1. Other than the anchovies (Engraulidae), the most numerous fish families were the following: mojarras (Gerridae), killifishes (Cyprinodontidae), mullets (Mugilidae), silversides (Atherinidae), and porgies (Sparidae).

During the past 7 months, these families contributed from 80-99% of the standard monthly catch.

The abundance of juvenile striped and bay anchovies in June contributed to peak seine catches in that month.

The largest mean catch with the otter trawl occurred in October and was due to an abrupt increase in the numbers of pinfish (*Lagodon rhomboides*), predominantly a forage and baitfish, and gray snapper (*Lutjanus griseus*), one of the most frequently caught sportfish in the Flamingo-Snake Bight area.

By species, the largest total number in the standard monthly collections were recorded in June (46 species) and October (57 species).

*Absolute abundance - Biomass.* The current study represents the second time that measures of biomass (wet-weight of individual) were utilized to determine the relative abundance of fishes in Florida.

It is anticipated that these data will be comparable in terms of biomass to the results of the South Florida Ecological Study on the western border of Everglades National Park and consequently yield valuable sport and commercial fish resource information

The total biomass of fish through November 1973 collected at regular stations is 142.6 kg.

By biomass, the most abundant fishes or monthly collections in decreasing order were the south stingray (*Dasyatis americana*), silver jenny, lemon shark (*Negaprion brevirostris*), whose major spawning grounds includes the Florida Bay area, striped anchovy, gold-spotted

topminnow, pinfish, and snook, one of the most sought after sport fish in park waters.

The monthly distribution of the dominant fish families in the regular catch by biomass is shown in Table 2.

The monthly sample catch at the regular stations by family demonstrated that the single species of Sphyraenidae, the great barracuda, a popular gamefish of Florida Bay, also dominated the fish biomass.

Four families of fishes--Engraulidae, Sparidae, Gerridae, Cyprinodontidae--dominated the fish fauna of the study area as measured by biomass as well as numerically.

On a biomass basis, these families comprised 51-98% of the monthly catch.

A total of 4360 pink shrimp was collected from the regular monthly collections. Numerically, the largest number of pink shrimp in the standard collections were recorded in August-September 1973, representing 52% of the total catch.

In addition, a tentative migration pattern has been established for the estuarine-dependent and commercially important pink shrimp (*Penaeus duorarum*) through northwestern Florida Bay. Pink shrimp provide Florida with its most valuable fishery resource. Upon completion of the yearly sampling period in July, the data will be analyzed for final results from Area I. A reference collection has been established for all specimens collected within the park. Several fish specimens taken are previously unreported from the Florida Bay area within Everglades National Park.

As time permits, special projects involving the volumetric stomach analysis of juvenile barracuda and juvenile lemon sharks are conducted in conjunction with the biological sampling schedule in northwestern Florida Bay. Qualitatively, the main food items of juvenile barracuda have been cyprinodonts, while lemon sharks have fed primarily on gerrids and cyprinodonts.

Study schedules should continue as planned. However, at the present time, I recommend that extension of otter trawl sampling in northwestern Florida Bay at least through July 1973. Results will eventually be correlated with sport and commercial harvest rates.

Table 1. Most abundant families of fishes by number as percent of monthly catch from the regular stations in northwestern Florida Bay (Area I) 1973

Family	May	June	July	Aug	Sept	Oct	Nov
Engraulidae	95.0	12.0	4.5	30.0	12.5	7.0	4.0
Cyprinodontidae	1.9	41.5	86.0	23.0	53.0	43.0	70.5
Gerridae	2.0	9.0	8.0	25.5	27.0	26.5	20.0
Atherinidae	<0.1	3.5		1.0	4.0	14.0	0.3
Mugilidae	0.7	17.0		0.2	0.3	0.3	0.2
Sparidae	0.2	2.0	0.3	0.6	0.2	4.0	3.0
Total	99.8	85.0	98.8	80.3	97.0	94.8	98.0

Table 2. Most abundant families of fishes by biomass as percent of monthly catch from the regular stations in north-western Florida Bay (Area I) 1973

Family	May	June	July	Aug	Sept	Oct	Nov
Dasyatidae		57.0	54.2				
Carcharhinidae	12.3	2.3	32.2			18.0	1.0
Engraulidae	52.0	0.5	0.1	3.2	1.6	0.2	0.4
Cyprinodontidae	4.4	3.1	8.0	7.9	24.1	4.2	22.4
Gerridae	10.1	6.7	3.1	32.3	16.9	12.8	14.1
Centropomidae		12.5				14.4	
Sparidae	<u>1.1</u>	<u>1.9</u>	<u>2.8</u>	<u>9.1</u>	<u>1.1</u>	<u>24.2</u>	<u>15.7</u>
Totals	79.9	84.0	97.4	52.5	43.7	73.8	53.6

# # #

FLORIDA BAY BENTHIC MAPPING PROJECT  
EVER-N-37

INVESTIGATOR: Thomas W. Schmidt  
National Park Service

OBJECTIVES: To characterize and map Florida Bay benthic features through the utilization of aerial photography and ground-truth surveys.

For convenience refer to: Area I as northwest Florida Bay  
Area II as central Florida Bay  
Area III as east Florida Bay

METHODS: Methodology includes aerial photography through the utilization of ortho-photography supplemented by biological sampling gear including a 4.2 m semi-balloon bottom trawl, 15.2 m beach seine, and a 15 cm<sup>2</sup> Ekman bottom dredge.

RESULTS AND DISCUSSION: The distribution of fishes and macro-invertebrates in the biological sampling area of Florida Bay (Area I) are significantly related to ecological differences among and within various estuarine and lacustrine habitats. However, since the incorporation of this projects field work in May, the occurrence of individual species by habitat can, at the present time, only be characterized within the biological study sites by benthic features. With the advent of complete ortho-photography during the next 1.5 years covering the entire Florida Bay area within the park, the total picture can then be presented.

A summary of preliminary results on representative benthic habitats of biological sampling stations with their brief descriptions follow:

*Seine Stations:* Mean water depths at all seine stations are approximately 0.8 m.

*Flamingo--* adjacent to marker 18 at the entrance of the Buttonwood Canal. Occasionally estuarine, with a very soft organic mud substrate characterized by limited amounts of turtle-grass (*Thalassia testudinum*) and shoal grass (*Diplanthera wrightii*).

*East Cape Sable--* normally marine, this station is located approximately 21 km west of Flamingo. Generally a moderate to high energy surf zone, depending on hydrographic

disturbances with a substrate laden with numerous molluscan bivalve shells adjacent to a quartzite sand beach. Vegetative cover consists of a sparse amount of attached red algae mostly *Acanthophora* spp.

*Sandy Key*--located approximately 10 km south of East Cape Sable, consists of a low to moderate energy surf zone characterized by a shell-quartzite sand substrate with an adjacent sea grass bed composed mainly of turtle grass and scattered amounts of shoal grass. Occasionally intermixed with the marine phanerogams are clumps of attached red algae (*Gracilaria* spp., *Acanthophora* spp., and *Laurencia* spp.) and coralline red algae (*Goniolithon*).

*Murray Key*--located immediately southwest of Flamingo and is characterized by a soft mud-marl benthos, covered with a sparse amount of shoal grass and attached red algae, mostly *Gracilaria* spp.

*Clive Key*--this region, located approximately 2 km south of Murray Key, represents a substrate heavily vegetated with turtle grass with very limited amounts of shoal grass and manatee grass (*Syringodium filiforme*).

*Man-o-War Key*--essentially marine, this station, located south of Clive Key, consists of a low energy surf zone characterized by a shell-quartzite sand substrate bordered by a moderate accumulation of shoal grass.

*Joe Kemp Key*--located immediately southeast of Flamingo, fluctuating between estuarine and hypersaline conditions during the initial phases of this study, is composed of approximately equal amounts of turtle and shoal grass on a soft mud-marl substrate with small clumps of attached red algae, notably *Acanthophora*.

*Palm Key*--adjacent to Joe Kemp Key, this region is characterized by an aggregation of branched red algae, usually *Gracilaria*, on a richly organic soft mud substrate with sparse amounts of shoal grass.

*Bottom trawl stations*--mean water depth approximately 1.5 m.

*Joe Kemp Channel*--located on the southeast edge of Joe Kemp Key--leads directly into the Snake Bight area, one of the most productive sport fishing zones in Area I. The substrate was dominated by turtle grass and at times, dense accumulations of shoal grass on a substrate underlain with small oolitic rock outcroppings.

*Conchie Channel*--this station, located approximately 5-6 km southwest of Flamingo, is a deep tidal channel with a benthos comprised mainly of hard-packed shell and quartzite sand.

*Palm Key Basin*--immediately south of Palm Key, this station receives a limited amount of tidal exchange and is characterized by a substrate consisting of heavy concentrations of the three dominant sea grasses, although manatee grass appears to be the dominant cover during the early phases of the study. Marine filamentous green algae occasionally was collected in dense concentrations, especially during the month of October.

*Rabbit Key Basin*--this station is found approximately 1.5 km southeast of Man-o-War Key and is essentially enclosed by a heavily vegetated, mostly *Thalassia*, marl bank. The sample site receives minimal tidal exchange from primarily one deep channel (2 m) on the western border of the basin. Again, the substrate is dominated by turtle grass with lesser amounts of shoal grass and *Halophila* spp.

Conclusions will be presented in respect to biological sampling and habitat quantification sites at the end of Area I's study schedule. Studies should continue as planned although currently it appears that additional technical support will be necessary to conclude this program by the projected completion date.

INORGANIC NUTRIENT UTILIZATION BY AQUATIC VEGETATION  
OF THE FLORIDA EVERGLADES  
EVER-N-49

INVESTIGATOR: Kerry K. Steward  
U.S. Department of Agriculture

SUMMARY OF PROGRESS: The studies' two objectives have been met: (1) to determine the nutrient removal capability of Everglades vegetation as a means of determining the feasibility of renovating wastewater; and (2) to determine the effects of increased nutrient levels on the vegetation.

1) The results of field studies indicate that sawgrass, the dominant plant species, has a low nutrient requirement and a limited capacity for removing nutrients from water. After 22 weekly applications of 2.2 kg/ha phosphorus to experimental plots, 12% was absorbed by sawgrass, 5% remained in the water, 3% was contained in algal blooms, and 44% settled to the bottom. In earlier studies, increasing rates of nutrient treatment increased absorption of phosphorus from 5% of the amount applied at 11kg/ha to 25% at 112 kg/ha. Because of this low capacity for nutrient absorption, it is unlikely that sawgrass plants could be used efficiently to renovate wastewater with high nutrient concentrations. It was estimated that sawgrass utilized a maximum of 1.8 kg/ha phosphorus per year in growth. Assuming the utilization rate were doubled, 461,000 ha (1.1 million acres) of sawgrass would be required to remove the phosphorus contained in the wastewater presently being discharged into inland canals of the three-county area of the lower east coast (829,000 kg P in 82.0 million M<sup>3</sup> water per year). The areas of the Everglades which could be utilized for recycling water are approximately 348,624 ha in size and contain a sawgrass cover of 70% or less.

2) The submersed plant species normally associated with sawgrass were eliminated as a result of dense algal blooms produced by the nutrient enrichment. The periphyton community normally present as a floating mat or attached to other plants was also eliminated. The results of greenhouse studies indicate that vegetative propagation, the primary means of propagation in sawgrass, may be inhibited by high tissue concentrations of phosphorus.

RECOMMENDATIONS: Investigator's recommendation for future research is that further studies be conducted to determine the highest nutrient levels which may be assimilated by the vegetation without adverse environmental effects.

# # #

PAST ENVIRONMENT FROM HISTORICAL SOURCES  
EVER-N-0050

INVESTIGATOR: Charlton W. Tebeau  
University of Miami

SUMMARY OF PROGRESS: Using principally narrative sources, nontechnical, noninvestigatory, and nonofficial, the effort was to gather meaningful descriptions of the environment. It very early became obvious that quantitative results except in most general terms would be impossible. It is possible to see the disappearance of the Carolina parakeet in the way observers call attention to its disappearing numbers, but not to establish numbers or the last sighting. What emerges is not a blueprint but a word picture of what Florida was like and what was happening to it. Significantly, the interior of the peninsula was not really known until just about 100 years ago when sportsmen and naturalists began to visit the area and report

their observations. Already the wildlife was being threatened. Very soon thereafter drainage and other development activities began to alter the landscape and the environment. Within 75 years the only original environment preserved to any great degree was in the Everglades National Park, but even there significant changes had taken place and some species had disappeared. In 1873 almost all of Florida, and certainly all of South Florida, could have been called a great biological preserve. In 1973 even those areas consciously protected were in some degree threatened. An important by-product, in fact a major part of this project, was the assembling of a collection of these source materials for further reading by interested persons. At this date, it is to be placed in the library at Everglades National Park Headquarters.

# # #

SPORT FISHERY STUDY  
EVER-N-53

INVESTIGATOR: Gary E. Davis  
National Park Service

OBJECTIVES: This study seeks to establish methodology and data processing techniques by which total sportfishing harvest from Everglades National Park may be determined and evaluated in terms of impact on the park resources.

METHODS: Catch and fishing effort data were collected by interviews with fishermen at the completion of their fishing trips. Catch rates were calculated for all important elements of the fishery using NPS computer facilities in the Office of Systems Design, WASO. Total fishing pressure was estimated by regressing boat ramp counts on total boating use data from aerial surveys, modified with party composition data from the dockside interviews.

RESULTS AND DISCUSSION: The kinds of input information needed have been defined. The composition and form of the output have also been defined. Contact with the fishing public has been established, and a good rapport has resulted. Channels for data processing have been roughed out, and initial runs of the FY 72 data have been made. The boating use information shows that that activity in the park is controlled by two major factors: day of the week and season. Substantially improved estimates of boating use patterns are available for 1973, which will make possible a realistic analysis of catch rates and fishing pressure. Increased interviewing, over past years, has reduced the variability of catch rate estimates, thereby improving the precision of our estimates of the relative abundance of Snook, Spotted Seatrout, Red Drum, and Gray Snapper.

PLANS FOR 1974: Interviewing will continue but will be concentrated on weekend fishermen. A few refinements in the logistics of data processing are in order. Once they have been solved, the program should operate on a routine basis with quarterly and annual reports arriving in the park 30 days after submission of the data.

COMMERCIAL FISHERY STUDY  
EVER-N-54

INVESTIGATOR: Gary E. Davis  
National Park Service

OBJECTIVES: The objective of this project is to establish a data collection and analysis system from which total fishery harvest and population dynamics of major species can be estimated.

METHODS: Catch and daily fishing effort data are collected from reports submitted by guide and commercial fishermen monthly. Catch rates and summaries of total catches will be calculated by NPS computer facilities in the office of Systems Design, WASO.

RESULTS: Catch and fishing effort data have been collected and transposed to machine readable formats for FY 72 and the 1st quarter of FY 73. Analysis requirements have been defined. Program development will be accomplished in early 1974. Analysis should be complete by July 1974, and a routine for regular data submission established.

DISCUSSION: Without complete analysis, very little can be said of the condition of the overall fishery. The stone crab yield continued to fall through the season in 1973. In April, the catch rate dropped below 0.1 of a pound of claws per trap night. This appears to be the lowest catch rate that will support the existing fishery at current prices. When the rate approaches 0.1 pound, fishermen moved their traps to more productive areas outside the park. This fishery is not producing a sustained yield in the park.

PLANS FOR 1974: Program development for ADP will be completed and comparative data for FY 72 and 73 will be available. Catch and effort data will continue to be collected.

# # #

LOW-LEVEL TEMPERATURE INVERSIONS IN THE MIAMI, FLORIDA AREA  
EVER-N-60

INVESTIGATOR: Harold P. Gerrish

OBJECTIVES: To provide a comprehensive seasonal analysis of low-level temperature inversions in the Miami, Florida area.

METHODS: The 268-ft AT&T Pennsco radio tower was instrumented to collect temperature data at the 205-ft, 105-ft, and 5-ft (ground) levels during the period 22 February 1973 to 30 April 1973. These data together with data previously collected on other towers locally provided the input for the study.

RESULTS AND DISCUSSION: Relatively strong low-level temperature inversions persisted significantly longer in the Pennsco area than in any other area studied. This means that the Pennsco area would be one of the poorest areas in South Florida for dispersing low-level pollution. Moreover, the discovery that spring inversions are generally stronger with winds from the east leads to the conclusion that all rural areas downwind from the urbanized lower east coast would exhibit poor nocturnal dispersion characteristics. Apparently, the warmth of the adjacent ocean waters together with the urban heat plume are responsible for the enhancement. In

other words, the natural geography and urban development complicates dispersion in southeastern Florida.

The seasonal variation in inversion strength is quite likely related to the fact that the dry season is characterized by large-scale subsidence (sinking of the air) which inhibits convection and makes inversion formation easier. In the wet season, rising air currents tend to make inversion formation more difficult.

Documentation of daytime inversions further substantiates the need to adopt a concerned attitude toward pollution potential in all forms of planning in South Florida. It is alarming to observe that the mean structure of the spring atmosphere in rural areas is that of an inversion, and that inversions occur more often than any other atmospheric structure during that period. This finding is of paramount importance in planning for projects which are to be located outside of the heat island--such as the proposed Jetport, nuclear power plants, cross-Florida highways, etc. Moreover, it admonished us to be more restrictive in permitting the open burning of fields, etc., during these months

CONCLUSIONS: The study produced the following conclusions:

1. Inland inversions form almost every night and are much stronger than those on the coast in South Florida. On the average, inversions are slightly stronger at the Everglades Tower than at Pennsuco, but persist longer at the Pennsuco Tower (14 hours as opposed to 12).
2. The tops of the low-level inversions generally extend above the 200-ft level.
3. Inland inversions during the spring form punctually at 1800 EST at the Pennsuco Tower, 1900 EST at the Everglades Tower, and lift off the ground punctually the next morning at 0900 EST (Pennsuco) and 0800 EST (Everglades Tower).
4. Inversions lift off the ground in the morning, and persist in the 100-to 200-ft layer for an hour or two before being lifted to greater heights. Inversions reform aloft in this layer beginning about 1600 EST, an hour or two before being observed again at the ground.
5. The mean temperature profile over inland areas during the spring is that of an inversion. Also, inversions occur in those areas more frequently than any other temperature structure.
6. The strongest spring inversion observed in the 200-ft layer at Pennsuco was 23.0°F, and 18.5°F at the Everglades Tower.
7. Inversion strength is inversely proportional to surface wind speed.
8. In the spring of 1971, the surface winds at Turkey Point were not as strong as those at Miami International Airport during the day, but were generally stronger at night.
9. Spring inversions west of Miami are strongest when the surface wind is from an easterly direction, especially a northeasterly direction.
10. Fifty-five percent of the inversions at Pennsuco occurred with wind speeds of 6-10 knots. Five percent occurred with speeds of 16 knots or greater.
11. There is a seasonal variation in the strengths of both coastal and inland inversions in South Florida. Inversions are strongest in the dry season.
12. Relatively strong inversions can and do occur during the daytime for periods of 1 or 2 hours in association with troughs aloft, cold frontal passages, sea-breeze fronts, and possibly cold outflow of air from shower activity.
13. There is little or no correlation between the air quality in downtown Miami and the inversion strength at Pennsuco.
14. A heat island exists in the Miami urban area and the heat plume aloft from it extends downdwind at least to the Pennsuco Tower.

PLANS FOR 1974: Although this particular project was completed during 1973, I do feel that the findings and their importance to the entire realm of air pollution and public health in South Florida demand further work in this area. Accordingly, I will be proposing to extend the study to a tall tower such as a 1000-ft television tower. This will provide greater detail and will help us to understand the life history of low-level temperature inversions.

REFORESTATION/RECLAMATION OF ABANDONED FARMLAND  
EVER-N-61

INVESTIGATOR: Larry Bancroft

OBJECTIVES: 1. To determine the best mechanical method that will reclaim the abandoned farmland. 2. To determine the best method to revegetate the land with more natural vegetation.

METHODS: Six experimental plots were established in different aged farmland. The following mechanical methods were used to test the best way to reclaim the land.

1. Bulldozing with rake.
2. Bulldozing with blade.
3. Chopping.
4. Disking.
5. Burning.

Transects 1 X 30 m are established at each site. The transect is treated as 30 m<sup>2</sup> quadrats. The transects are photographed prior to treatment of the plot and will be photographed every 2 months for 2 years. Cover estimates are made for each quadrat. The purpose is to determine the effects of the various techniques upon plant succession.

Several one quarter-acre plots are used to test the feasibility of planting pine seedlings and grass seed. Each plot will be photographed and surveyed every 2 months for the duration of the study.

RESULTS: Results are tentative at this time because of the short duration of the study. Bulldozing with rake appears to be the best method for removing the dense hardwood growth on the old farmland.

DISCUSSION: Because of the delicate nature of the land and the lowered water level, hardwood (primarily exotics) rapidly invade the abandoned farmland. This process usually occurs in less than 5 years. Once the exotics (Brazilian holly and Juava) and other hardwoods claim the site, it is impossible to reclaim the area without great expense -- \$80/acre for bulldozing.

Of even greater importance is the need to eliminate the exotic plants. Unless controlled, they are capable of invading natural areas. It is hoped that this research program will give us the answers to reclaiming the abandoned farmland prior to July 1975. At that time, the remaining 5000 acres of farmland will become park property.

CONCLUSIONS: None at this time.

PLANS FOR 1974: All six sites have been treated and pine seedlings and grass seed planted. We will follow plant succession during 1974.

# # #

ECOLOGY AND TAXONOMY OF RACCOONS  
EVER-N-62

INVESTIGATOR: James D. Lazell, Jr.  
Massachusetts Audubon Society

SUMMARY OF PROGRESS: Two very distinct kinds of raccoons occur together throughout the park. The *elucus* raccoon seems to mature at about 6-8 lbs and reaches at least 20 lbs. It has a prominently bowed forehead and conspicuous orange-yellow pelage tones, especially in the form of an obvious nape patch. The *elucus* raccoons are found in groups of two or more adults and several young; they are very communal and respond immediately and positively to a standard Olt 'coon squaller.

The *marinus* raccoon seems to mature at 3-4 lbs and reaches about 8 lbs. The forehead is not bowed, and the colors are somber. If a nape patch is present at all, it is a mere brownish wash on an otherwise grey animal. We always encountered *marinus* raccoons singly. They respond immediately and negatively to the squaller: they run away in apparent terror.

The *elucus* raccoon prefers the dry substrate of the pine keys and hammocks. The *marinus* raccoon prefers the watery substrate of the mangroves. We have collected them exactly together, however. I can see no way that these two forms can be "subspecies." Before publishing on their status as apparently full species, however, I would want to conduct a full computer analysis of their morphological differences and to obtain data on blood proteins and karyotypes. I do not know when I can undertake this. Funding is obviously a problem.

All specimens collected will be deposited in the Museum of Comparative Zoology, Harvard, subsequent to completion of examination.

Specimens of *elucus* raccoon (1)-Baculum only: a DOR, 2.5 mile E Ioris. (2) Skull only, found in marsh 6 mile SW Ioris. (3) Adult ♂ skin and complete skeleton: 4 mile S Ioris. (4) Molariform teeth only/ a DOR in median strip, Flamingo. (5) Skin and Skeleton: 4 mile NE Flamingo.

Specimens of *Marinus* raccoon: (1) Skin and Skull: 4 mile NE Flamingo. (2) Complete skeleton: Park boundary, E side, 6 mile S. Tamiami Trail.

# # #

#### WATER QUALITY ANALYSIS OF FLORIDA BAY EVER-N-64

INVESTIGATOR: Thomas W. Schmidt  
National Park Service

OBJECTIVES: To determine and evaluate hydrographic parameters of Florida Bay including salinity, temperature, conductivity, dissolved oxygen, hydrogen ion concentration, and turbidity.

Data will be used to assist in the analysis of baseline ecological information for the formulation of sound resource management plans of sport and commercial fisheries indigenous to the Florida Bay portions of Everglades National Park.

For convenience refer to:  
Area I - northwestern Florida Bay  
Area II - central Florida Bay  
Area III - eastern Florida Bay

METHODS: A total of 38 water quality stations have been established throughout Florida Bay during preliminary biological surveys and hydrological surveillance schedules.

Those stations located within the biological study Area I are sampled bimonthly while all other stations (Areas II and III) are checked monthly. Sites in areas II and III

were selected in consideration of the potentiality of future biological sampling stations. Environmental parameters measured included conductivity (mhos/cm), salinity (ppt), temperature (C°), dissolved oxygen (mg/l), pH, and turbidity (FTU's). Measurements of most parameters have been made from May through November 1973.

**RESULTS AND DISCUSSION:** At the lower reaches of the Florida Bay estuarine system, salinity readings ranged from 6.0 ppt in Area III to 42 ppt at Flamingo in Area I.

If subsequent salinity readings at Flamingo continue to approach normal marine salinities (35-37 ppt), a salinity gradient may become established near the entrance of the Buttonwood Canal thus permitting marine predators to feed on important sport and commercial species (fish, crabs and shrimp) during their larval and juvenile life history stages in the estuary. Furthermore, high salinities will deprive these species of a salinity transport mechanism, a system which requires their migration to low salinity and freshwater areas for normal morphological development.

Central Florida Bay lacustrine basins salinity readings ranged from 29.0 ppt to hypersaline conditions of 55 ppt. Higher salinity readings are probable during the next several months as the "dry season" traditionally begins in the month of December.

Temperature readings ranged from 23°C in early May to 33°C during the month of September throughout Florida Bay.

Dissolved oxygen readings began in September with a recorded low of 5.9 mg/l near Flamingo to a maximum of 12.2 mg/l during the day at Palm Key (Area I). pH has been recorded since August in the biological sampling area and since September throughout Florida Bay. Minimum and maximum readings of 7.0 and 9.7 were recorded in eastern Florida Bay and in the central lacustrine basins, respectively. Turbidities have been generally low to moderate since May, 0.3 to 4 throughout the Bay, however wind-induced turbidities during October and November approached 34 FTU's near the East Cape Sable area.

Since this project is still in progress, no significant conclusions will be presented at this time. The work should proceed as planned.

# # #

#### SHARK SLOUGH STUDY (ESTUARY) EVER-N-65

**INVESTIGATOR:** Gary E. Davis  
National Park Service

**OBJECTIVE:** This study seeks to relate water management in the Shark Slough to the biotic elements in the system. Timing, quantity, and quality of the water released into the upper Shark Slough controls biological production and community structures from the point of entry through the everglades to the estuary at the Gulf of Mexico. Recent water regimes have not supported stable wading bird populations in the slough. As adjustments are made to the water releases into the slough, the impact on the total system is being evaluated.

**METHODS:** Water quality in the estuary and lower reaches of five major rivers is being recorded at 14-day intervals. Quantitative biological samples are being taken of the estuarine epibenthic communities and ichthyofauna.

**RESULTS AND DISCUSSION:** Sampling stations have been established on the five substrates found in the estuary. Initial water quality analyses begin to document the seasonal cycles necessary to maintain the ecosystem.

PLANS FOR  
1974:

Continue the sampling and water quality work.

# # #

## SHARK SLOUGH FISH PRODUCTIONS RELATED TO WOOD STORK NESTING SUCCESS EVER-N-66

INVESTIGATOR: John C. Ogden  
National Park Service

SUMMARY OF PROGRESS: The primary accomplishment during calendar year 1973 was the compilation of data from earlier Wood Stork field surveys, and other everglades biological and hydrological records considered important as a base for the present study. Field work on this new project was initiated during November 1973, when Jim Kushlan and Jim Tilmant began quantitative fish trapping at predetermined, fixed sites in the Shark Slough and on Cape Sable. They also began trapping at Wood Stork feeding sites as determined by aerial surveys. I also spent some time in December watching stork feeding behavior, quantifying catch rates, and feed efficiency.

## FIRE ISLAND NATIONAL SEASHORE

### ENVIRONMENTAL INVENTORY OF NON-FEDERAL LANDS WITHIN THE FIRE ISLAND NATIONAL SEASHORE, NEW YORK

INVESTIGATORS: Jack McCormick Associates) Pennsylvania  
William P. Gregg, Jr. ) Denver Science Center

SCOPE OF STUDY: The study is being undertaken to obtain information on the environment of non-Federal lands within Fire Island National Seashore and to provide an objective basis for decision-making with respect to Federal involvement in the management, use, and development of such lands. The study is being done as part of a master planning effort for the seashore, which is currently in progress.

The following inventories are being made on the non-Federal lands:

*Land Use Inventory.* A summary of existing land uses on non-Federal lands, containing the following:

- a. Map (1 inch = 400 ft) showing different land uses (commercial, residential apartment/motel, recreational, nature reserve, undeveloped open space, dumps, etc.).
- b. Acreage tabulations for all land uses in each political unit.
- c. Description of proposed land uses, where plans are known. Indicate graphically locations of proposed changes in land use (map 1 inch = 400 ft).

*Land Ownership Inventory.* A summary of existing land ownership for each political unit is being prepared in cooperation with the Lands Office of the Northeast Regional

Office of the National Park Service in Philadelphia. The inventory will include:

- a. Acreages in private, municipal, county, state, or other ownership.
- b. Assessed valuation of, and property taxes from, privately owned lands in each political unit.
- c. Approximate number of year-round residents and summer residents in each political unit.
- d. Tabulation of the number of improved properties in various classes for each political unit.
- e. All other material normally included in the National Park Service lands inventory that accompanies legislative proposals for land acquisition.

*Development.* A description of the existing development in each political unit is being made. Emphasis is being placed on the level of development and the kinds of activities the developments facilitate. Development that allows for public recreational use of land is being inventoried in detail (e.g., number of overnight lodging units and number of pillows in each, number and size of marinas, number of public beaches, and size of support facilities, etc.)

Existing methods of marine, domestic, and municipal sewage treatment are being described, their efficiencies evaluated, and their present and probably future effects on the environment analyzed. An estimate of the number of various types of sewage treatment facilities and an assessment of the total pollution load at various times of the year will be made. The locations of any systems known to cause serious local pollution will be mapped (1 inch = 400 ft).

When integrated with appropriate economic, social, and ecological factors, the development inventory should facilitate assessment of the optimal capacity of the non-Federal portion of the national seashore for various kinds of use. Factors which limit the ability of the environment to accommodate use and development will be evaluated. Where environmental deterioration due to overuse and development is occurring, existing conditions will be described and the degree to which use-capacity has been exceeded estimated. A thorough analysis of the ability of these areas to absorb existing and projected levels of use without unacceptable disturbance will be carried out. This analysis of optimal capacity for use will also include the three major federally developed areas at Sailor's Haven, Talisman, and Watch Hill.

The contractor is also reviewing existing aerial photography and other appropriate material to show the long trend in the development of the island.

*Evidences of Environmental Manipulation.* An inventory of all existing and proposed developments that may jeopardize the stability or long-term perpetuation of the barrier island is being made, accompanied by a map (scale 1 inch = 400 ft) showing the locations of all such developments. The inventory will include, but not be limited to, the following (with assessments of the known and probable adverse effects of each):

- (a) Groins
- (b) Seawalls
- (c) Jetties
- (d) Artificially-stabilized dunes
- (e) Homes and other development within 50 ft of the crest of the primary dunes
- (f) Marinas and other developments in the bayside tidal marsh zone

The contractor is reviewing existing aerial photography and developing appropriate graphics showing the long-term trends in the above types of development.

*Environmental Pollution.* An inventory of the existing sources and levels of environmental pollution is being made and the effects of these sources on natural ecosystems assessed wherever possible. Air pollution, estuarine surface water pollution, noise, degradation of aesthetics (by trash, deteriorating developments, etc.) degradation of the landscape due to vehicular use, and other types of pollution are being inventoried with reference to the ability of the environment to absorb them without deleterious effects. Feasible mitigating measures to reduce the adverse effects of existing pollution sources will be proposed

*Topography.* The report will depict the topographic features of non-Federal lands and will include topographic maps (scale 1 inch = 400 ft), maximum contour interval 4 ft. These maps are being prepared from existing topographic maps on file in the Denver Service Center.

*Geomorphology and Coastal Processes.* The evolution of the landforms of non-Federal lands is being described, with particular emphasis on historical changes in their configuration. If possible, sediment cores will be analyzed to help evaluate the island's sedimentary history. The locations of former inlets, zones of severe erosion, and zones of accretion are being described and mapped (scale 1 inch = 400 ft). The rates of sedimentation, erosion, and island migration are being assessed, if possible, using computer simulation techniques or other appropriate methods. Profile diagrams will be provided as necessary. The need for environmental manipulation to stabilize landforms in order to protect development will be discussed.

*Soils.* Soil characteristics are being described and different soil conditions mapped (scale 1 inch = 400 ft).

*Groundwater Hydrology.* An inventory of groundwater resources is being made. The yield and water quality of a representative sample of existing wells is being assessed and the ability of existing groundwater reserves to sustain additional development evaluated. The known and probable effects of saltwater incursion into near-surface and deep aquifers are being evaluated and the implications of such incursion on the long-term development and the natural ecosystems of Fire Island elucidated. The locations of all artesian wells are being mapped (scale 1 inch = 400 ft).

*Vegetation and Flora.* A vegetation map for the Federal portion of the seashore was prepared in 1971. The map is being expanded to include the non-Federal portion and is being drawn to the same scale using the same mapping units as the 1971 map. The successional status, condition, productivity, and physiognomy of vegetation is being described. A preliminary floristic list, compiled as part of the 1971 study, is being expanded to include the non-Federal district. Particular attention will be accorded the identification and location of individuals or populations of exotics. Similarly, the identification and location of populations of rare, endemic, or otherwise remarkable species will be made.

*Fauna.* A preliminary faunal list, prepared for the Federal district in 1971, is being expanded and annotated to provide information on the abundance, habitat affinity, and the status of existing populations (where known).

*Estuarine Quality.* An assessment of the quality of the estuarine environment within the authorized boundaries of the seashore is being made. Recent trends in productivity and diversity are being evaluated and those factors that influence the vitality and vigor of this environment described. Particular emphasis will be placed on determining the effects of existing activities--such as recreational boating, crabbing, clamming, and commercial fishing--on estuarine quality.

*Assessment of Storm Damage.* Storm frequency and intensity, as well as the extent and nature of storm-induced changes in the island's landforms during the recent past, will be evaluated in as much detail as possible, along with an assessment of the economic effects of these changes.

*Historical, Cultural and Archeological Resources.* An inventory of all historical, cultural, and archeological resources of the island and adjacent waters is being compiled. The significance of each structure or site will be assessed and, where structures or artifacts exist, the condition of the resource will be described. Existing threats to the preservation of historical and archeological resources will be discussed.

*Need to Maintain Federal Presence on Existing Non-Federal Lands.* The contractor will make recommendations as to the desirability of maintaining a Federal presence on existing non-Federal lands. The desirability of Federal land acquisition in specific locations will be indicated and the environmental implications of such acquisitions delineated.

The environmental inventory of non-Federal lands without Fire Island National Seashore will be completed on or before 1 October 1974, with components of the study to be submitted to the Denver Service Center periodically from 1 April to 1 October. At this writing (1 March 1974), the study is proceeding on schedule. Upon completion of the study, the recommendations in an existing draft master plan will be amended, as necessary, to minimize adverse effects on the natural, social, and economic environment of the area. If possible, a suggested priority system for Federal acquisition will be presented.

# # #

## HABITAT SELECTION AND OTHER ASPECTS OF SONGBIRD MIGRATION AT FIIS

INVESTIGATORS: P. A. Buckley  
F. G. Buckley

OBJECTIVES AND METHODS: Begun in 1969, this study is multi-purpose, designed to answer several basic as well as applied/management questions. Numerous additional ancillary projects have also developed naturally from it. Basically, it involves a continuous sampling, by means of mist nets, of land birds passing along the beach in migration in the vicinity of Fire Island, Lighthouse, all year long. All birds were marked with numbered aluminum bands to keep track of individuals. Two study areas were established: one in a pitch pine grove; the other in a long stretch of deciduous vegetation, both of which had canopies barely 10 ft high. We had reason to believe that certain species were preferentially choosing the pine grove; that before spring leafing-out and after autumn leaf-fall, most species avoided the deciduous area; that in the normal course of migration at ground height most birds moved through the pine grove until later in the day, even when deciduous areas were in full leaf; that birds remained longer in the pine grove, whether expressed in hours after initial capture on the same day, or in days since initial capture; and that species diversity was greater in the grove on an hourly, daily, or even seasonal basis.

We were also interested in some basic aspects of migration: Are birds normally considered nocturnal migrants nonetheless continuing their migration through ground vegetation by day? If so, for how long, in what directions, in which seasons, and how does this relate to local weather conditions? Is there any micro-habitat selection demonstrable, where migrants normally occurring in the canopy of a 60-ft forest restrict themselves to the "canopy" of a dwarf maritime forest? Are there any species occurring in migration at FIIS not previously suspected, or occurring at times of the year previously unsuspected? Is landbird migration on the barrier beach there equally heavy in spring as well as fall? Does the pattern of birds banded there but recovered elsewhere tell anything about migration patterns previously unknown or verify any current hypotheses.

To answer these questions precisely, up to 20 English terylene mist nets, 12 m long, 3 m and 4 shelves (sections) high, were operated before dawn to as late as possible in the day, on as many days as possible, with both coniferous and deciduous substations operating simultaneously whenever personnel permitted. Precise data were taken on each bird in the net as to time, species, age, and sex if ascertainable externally, net lane, net #, side of net (all nets were perpendicular to the long axis of the barrier beach), and shelf. After field recording, all data were transcribed onto optical scan sheets for direct computer input, a painfully slow process still underway. (Having banded some 60,000 birds of 165 species, we have considerable data to handle). Programs for tabulation of the data have been/are now being written by associates at CUNY (Brooklyn College) and SUNY (Stony Brook), and while some results are already available, it will be some time before all data have been tabulated and then statistically analyzed.

RESULTS: We can now qualitatively answer some of the questions posted above and can even make one or two tentative quantitative statements. For example, we have ascertained that diurnal migration by normally nocturnal migrants continues throughout most of the day, spring and fall, generally tapering off by noon. Most migrants (68% of all birds in both spring and fall) are passing to the SW, often at rapid rates, usually below treetop level, through vegetation. This movement seems generally irrespective of ground wind direction, except that on NE winds (rather uncommon) more birds seem to head NE, following the beach but in the opposite direction from normal movement (SW). Microhabitat selection is obvious with birds like flycatchers (most, except *Empidonax*, preferring to sit on treetops, and hence are caught in the top shelf) or wrens and yellowthroats (ground foragers, usually in the bottom shelf). Other species--the vast majority--with less extreme habitat preferences are not making any obvious height choices; refined data analysis will be needed to unmask them if they are occurring.

In the course of our netting we uncovered significant new distributional data, including the regular occurrence of several birds previously considered only irregular vagrants to Long Island, such as Acadian Flycatcher and Red-bellied Woodpecker. We have recorded several extreme vagrants (one for the first time east of the Rockies), the data on which have just been published (see below). We have been able to show not only that the occurrence of great numbers of migrating passerines on the barrier beaches of Long Island was not restricted to the fall migration (as previously thought) but also that spring migration lasted well into mid-June and often beyond. Similarly, we have considerable data indicating that fall migration of even typically insectivorous birds lasts well into November, and many so-called "record late dates" for the New York City region were broken with regularity at FIIS, indicating the need for revised estimates.

Analysis of rapid recoveries of our banded birds (i.e., within a few days of banding at most) confirms the generally SWward movement indicated by our net data. In fact, one Black-poll Warbler we banded on 29 May 1972 at 0600 was recovered at another banding station one inlet and some 13 miles SW at 1200 the same day. This is one of the very few, possibly the only certain, same-day recoveries of a banded bird and is a nice demonstration of continued diurnal migration by a supposedly nocturnal migrant, in the general westward direction. This movement to inland locations by coastal migrants has been explained as their returning to their preferred inland (along the Appalachians?) migration route after having (been) drifted out to sea during the night. While this explanation has recently been called into question by radar studies of nocturnal migration, birds at FIIS in both spring and fall migration are uniformly heading (south-) westward, or inland, by day.

Data on habitat preference, length of time remaining in the area as a function of habitat type, species diversity in the two habitats, etc., must await statistical analysis before we can make any firm statements about effects. We can thus only affirm our inductive suspicion that pine groves are more productive at all times of the year for resting, feeding, and migrating passerines.

OTHER STUDIES: Several other studies were undertaken at the banding station or made use of its facilities and birds. A former student of PAB's did his M.S. Thesis on gut morphology adaptations of various warblers obtained there; another paper by him and others records blood parasites obtained from some of our birds; a colleague is now studying fat deposition by migratory thrushes netted there; and a Rockefeller University graduate student is investigating the wind tunnel behavior of interhemispheric migrants from the station.

FUTURE PLANS: The banding station was closed permanently in late November 1973 after we had obtained enough data to answer the questions originally posed. The data have been parceled into functional areas corresponding to certain of the main questions asked, the data transfer onto opscan sheets as well as program writing and debugging, followed by analysis, will continue until completed. It will be some time before results are available, but in addition to yielding basic ecological and ornithological information, they will have management implications for the relative merits to birds of deciduous vs. coniferous planting, extrapolable to most other areas of the county, probably including inland locations.

Pertinent literature:

- Buckley, P. A. 1973. A preliminary check-list of the birds of the Fire Island National Seashore area. [prepared for park distribution]. 5p.
- Buckley, P. A. 1972. 1971 fall migration at Fire Island Research Station. *EBBA News* 35:147-48.
- Buckley, P. A. 1973. 1972 fall migration at Fire Island Research Station. *EBBA News* 36:206-210.
- Buckley, P. A. 1974. Recent specimens of western vagrants at Fire Island National Seashore, L.I., New York. *Auk* 91: in press.
- Klem, D. 1973. A comparative study of alimentary tract anatomy and histology in relation to diet in selected North American Wood Warblers (Parulidae). Unpublished M.S. Thesis, Hofstra University, 42 p., 4 tables, 27 figs.
- Sonneborn, D. W., P. A. Buckley, and H. J. Hansen, 1970. Serum Vitamin B<sub>12</sub> binders from some songbirds (Aves; Passeriformes). *Am. J. Clin. Nutr.* 23:673

In preparation:

- Klem, D., P. R. Earl, and P. A. Buckley. MS. Blood parasites from some fall migratory passerines at Fire Island National Seashore, L.I., New York.
- Buckley, P. A., and L. Rems. MS. Scotland-ringed Parasitic Jaeger (Skua) recovered at Fire Island National Seashore, L.I, New York.

## FORT JEFFERSON NATIONAL MONUMENT

### TERN COLONY STUDIES

FOJE-N-2

INVESTIGATORS: William B. Robertson, Jr.) National Park Service  
O. L. Austin, Jr. ) Florida State Museum  
G. E. Woolfenden ) University of South Florida

HISTORY: Adequately outlined in earlier annual reports.

CY 1973: Work of the project in CY 1973 included two research trips to the colony totaling 15 days, in early May and in late June-early July. In addition, somewhat more time was available for work with accumulated data than has been the case in other recent years. But, lacking technician help, much of this time was by necessity given over to routine care of columninous project records. Findings and progress in the report period included the following.

*Field:* In early February, grass and herbaceous halophyte (*Sesuvium*, *Cakile*) vegetation was thinned with hand tools in much of the western and southern parts of the Sooty Tern colony, requiring about 10 man-days labor by the investigator and a resources management crew. This was done because a sharp increase in the mean age of breeding Sooty Terns and a sharp decrease in the number of young suggested that many younger adults failed to nest in 1972 due to the heavy ground cover in the nesting area and consequent shortage of nesting space. Vegetation management efforts appeared to have the desired results as the number of young Sooties banded increased from about 8700 in 1972 to about 23,500 in 1973. Banding effort was essentially identical in the 2 years and in each year the number banded was estimated to be 75-80% of the total production

of young Sooties. On the two trips combined, about 5300 banded adult Sooties were recaptured of which about 45% were birds of known age (3-14 years old). For the first season since 1959, we failed to recapture any of the Sooty Terns banded at Dry Tortugas in 1937-41. Two 32-year-olds remain the oldest known-age birds that we've handled and it may be that this is about their limit of longevity. Careful check of juvenile Sooty Terns revealed little evidence of premature feather loss or other developmental anomalies, so prominent in 1970 and little in evidence since. Cause of the 1970 episode is obscure as preliminary data show extremely low levels of both chlorinated hydrocarbon and heavy metal pollutants in Dry Tortugas Sooty Terns. Few of the 150 adult Sooties individually color-banded in 1972 returned to test plots although the plots were heavily occupied by nesting birds. Interpretation of this unexpected result must await later data, but it is possible that adults in this colony may not breed every year.

*Office, Library, Lab:* Progress with analysis and reporting phases of the work was perceptible but woefully inadequate. Approximate status of various reports by the investigator and collaborators is as follows:

*Movement and migrations from band recoveries* (Robertson): Recovery records brought up to date, some data analysis, preliminary writing. Estimated 20% complete as compared to status at end of CY 72.

*Comparative age structure of Sooty Tern populations of Dry Tortugas and at Johnston Island, Central Pacific* (Hardington, Dr. Woolfenden's student): Paper accepted for publication by *Bird Banding*.

*Demography of Dry Tortugas Sooty Terns* (Dr. Austin): In manuscript, but still needs considerable work. I reviewed several drafts of the paper in CY 1973.

*Pollutant concentrations in relation to age:* (Robertson and Drs. Riseborough and Connor, Univ. California): Estimated 10% complete, analyses begun after long delay apparently due to funding problems at Riseborough's lab, some preliminary results received.

*Wear of bands carried by Sooty Terns* (Dr. Woolfenden, Robertson): Estimated 50% complete. Bands weighed, weights tabulated, preliminary analysis. Knowledge of the rate of band loss due to wear is necessary for accurate calculations of mortality.

*Arrested molt of primaries, normal molt and plumage sequence in Sooty Terns* (Harrington, Robertson): Negligible progress.

*Food habits of Sooty Terns* (Robertson): Negligible progress.

**PROSPECT:** Hopefully, time and support available will permit more substantial progress with the above writing jobs in CY 1974. Unless forcibly restrained, I would hope to be able to continue field work on Tortugas terns gradually, redirecting the work toward more intensive studies. I hold firmly to the belief that good population studies require long tenure and that long-term, or even open-ended, studies are not necessarily inappropriate so long as the work remains productive. In my opinion, FOJE-N-2 has remained productive by whatever reasonable test one wishes to apply. It has in addition brought to an NPS area substantial free scientific talent and services (for example, in pollutant analysis). I'd maintain that one of the better ways to monitor an area's environmental health is by understanding in great detail populations of upper trophic level animals. At Dry Tortugas Sooty and Noddy Terns are two such animals.

SPINY LOBSTER STUDY  
FOJE-N-6

INVESTIGATOR: Gary E. Davis

OBJECTIVES: The objective of this study is to evaluate the impact of sport diver harvest on the Spiny lobster (*Panulirus argus*) population at the Dry Tortugas atoll.

METHODS: Spiny lobster population dynamics within the atoll system will be monitored by direct u/w observations, trap yields, and capture-recapture of tagged individuals. The population monitoring will take place over a 5-year period. The first 2 years no harvest was allowed. The 3rd year a sport harvest is being permitted using a two lobster per person per day limit. The 4th and 5th years will be used to assess impact and recovery from the harvest.

RESULTS AND DISCUSSION: During the first 2 years of the study, the residency of a population of spiny lobsters was established by tagging over 1200 individuals and comparing age structures with adjacent areas. Population levels and distribution of individuals and sexes have been found to vary with season, weather, and depth in a consistent pattern. In the fall (Sept.-Nov.) the bulk of the population is found in shallow water (less than 5 m) in living coral dens, principally large heads of common star coral (*Montastrea annularis*). As winter storms and cooler water strike the atoll in November or early December, 60-70% of the lobsters move to deeper water (10-25 m) where they take up residency in rocky dens encrusted with small living corals and alcyonarians. As spring approaches in March, there is a general movement of both sexes back toward the shallow coral heads, but during April and May the mature females, most bearing eggs, return to the deep dens, leaving the shallow heads populated by males and immature females. By mid-summer the mature females have begun to return to the shallow heads, eventually recreating the high densities (1500/ha) of large (6.2 kg) lobsters commonly seen during the late summer and fall at Dry Tortugas. Harvesting began on 1 August 1973. After 6 weeks, a 49% decrease in the expected numbers of lobsters was observed. This decline in numbers of lobsters increased to 62% after 14 weeks of harvest. Lobster numbers in unharvested control areas remained the same as they were during the 2 previous years through this same time period.

PLANS FOR 1974: We will continue to monitor population levels and distribution. Additional trapping will be necessary to compare before and after effects of the harvest of August 1973 and April 1974. More individuals will be tagged during the trapping operation to further determine growth and movement of the Tortugas lobsters.

# # #

SURVEY OF BEUTHIC ALGAE-TORTUGAS  
FOJE-N-7

INVESTIGATOR: Deborah White  
University of Texas

SUMMARY OF PROGRESS: I received permission to undertake this project while serving as a Student Conservation Association Volunteer at Fort Jefferson National Monument.

In light of my heavy schedule during my stay there, it was found that the project was not feasible.

However, under the direction of Gary Davis, I did gain much experience and familiarity with the reef environment.

## FORT NECESSITY NATIONAL BATTLEFIELD

### SOIL SUITABILITY INTERPRETATIONS FOR FORT NECESSITY NATIONAL BATTLEFIELD

INVESTIGATOR: Phil Dittberner  
Denver Service Center

SCOPE OF STUDY: The purpose of this study was to determine the suitability of the soil series of Fort Necessity for various kinds of developments and uses. The suitability was extrapolated from the Fayette County Interim Soil Survey Report, Soil Survey Maps, Volume I and Soil Survey Interpretations, Volume II and were based primarily on engineering interpretations. Completed in March 1974.

## FOSSIL BUTTE NATIONAL MONUMENT

### GEOLOGY OF FOSSIL BUTTE NATIONAL MONUMENT

INVESTIGATOR: Paul O. McGrew  
University of Wyoming

SUMMARY OF PROGRESS: The report on the geology of Fossil Butte National Monument is ready for final editing and preparation of illustrations. All significant research has been completed. The report will cover all geological and paleontological aspects of the monument area.

FOSSIL BUTTE NATIONAL MONUMENT VEGETATION MAP

INVESTIGATOR: Alan A. Beetle  
University of Wyoming

SUMMARY OF PROGRESS: The field work at Fossil Butte National Monument is finished. A vegetation map is being prepared. Preliminary survey indicates that this new National Monument has a history of grazing which has influenced the present vegetation. The future grazing problems will not be solved by a fence unless a management plan is developed. The feral horse situation is serious now and could easily be worsened by fencing. It is suggested this study be continued another year to document the grazing history and suggest management alternatives.

GLACIER BAY NATIONAL MONUMENT

THE HYDROLOGY AND INTERNAL DRAINAGE OF STAGNANT AND ACTIVE ICE  
IN THE BURROUGHS GLACIER, SOUTHEAST ALASKA  
GLBA-N-6b

INVESTIGATOR: Grahame J. Larson  
The Ohio State University

SUMMARY OF PROGRESS: All field work has been completed for this project. Raw data are now being analyzed and compiled and will be presented in a report 9/74.

# # #

GEOBOTANY AT LITUYA BAY, AK, WITH SPECIAL REFERENCE TO SECONDARY  
SUCCESSION ON SURFACE DEFORESTED BY THE GIANT WAVE OF 1958 (FOR  
COMPARISON WITH LONG-TERM PRIMARY SUCCESSION STUDIES AT GLACIER BAY)  
GLBA-N-9

INVESTIGATORS: Donald B. Lawrence )  
Elizabeth G. Lawrence) University of Minnesota, St. Paul

SUMMARY OF PROGRESS: Special emphasis was placed on the production of color photo and descriptive records of the current condition of the landscape and vegetation of the Lituya Bay area, especially the new vegetation developed on surfaces denuded by the Giant Wave of 1958. The 104 best of the total 238 color transparencies have been enlarged on paper in duplicate to 2.5 x 3.5 inches, paid for by the Ecology Research Fund (Lawrence), and these will illustrate the final report, one copy of which will be submitted to the Superintendent; the other is to be retained in the University of Minnesota Glacier Bay Research file. Four portions of the Lituya

Bay area were especially studied: (1) Cenotaph Island; (2) a rough transect from the north mainland shore of the bay to the summit of the Neoglacial right lateral moraine (Solomon Railroad) traversing forests grown up since the Great Waves of 1958 and 1853-54; (3) a rough transect from the mainland bay shore due south of the center of Cenotaph Island easterly to an elevation of about 400 ft; and (4) a detailed study of a newly established circular permanent plot, on the transect just mentioned, on a terrace within the area denuded by the Giant Wave of 1958. The plot is 35 steps (yds) mag. E. of the east edge of forest debris NE of the east edge of the pond.

**SIGNIFICANT FINDINGS:** (1) At Cenotaph Island on mineral soil exposed at the old forest margin by two large overthrown spruce tree root systems the importance is demonstrated of mineral soil for the establishment and continued growth on the adjacent undisturbed forest moss blanket just a few feet up slope. This observation suggests a model for commercial forest removal and regeneration in SE Alaska, by pulling over and uprooting the trees rather than merely cutting and leaving stumps and relatively undisturbed low nutrient moss blanket. Redevelopment of high nitrogen levels and availability of mineral nutrients necessary for rapid growth of another generation of Sitka spruce trees thus could be assured. If the trees were overturned down-slope, erosion could be greatly restricted also by the basins and root systems like terraced hillsides. (2) Near the crest of the Solomon Railroad moraine the wall of a shallow cave in outwash deposit revealed carved sediments that appeared to show marked periodicity in a sequence of approximately 11 layers (years?) suggesting influence of the 11-year sunspot cycle on glacier ablation as demonstrated earlier by Lawrence at Herbert and Mendenhall glaciers. (3) A fine area was found in about a two century old forest on mainland above the 1958 forest destruction area, south of Cenotaph Island, where *Sphagnum* moss was vigorously overgrowing *Hylocomium* moss blanket, demonstrating the initiation of forest paludification. At another place higher up, a new insight was gained on a mechanism by which pit ponds in muskeg may originate. Several skunk cabbage (*Lysichiton*) plants recently had been chewed away by some large animal, presumably a bear, producing a pit where the animal's muzzle had pressed deeply into the soft substratum in order to eat the foliage and upper part of the vertically oriented fleshy underground stem of each plant. It is expected that the decapitated skunk cabbage plants would regenerate from one or more of the axillary buds that ordinarily remain dormant. Young western hemlock trees up to 11 ft tall were growing well on the summit ridge of the line of 1958 wave forest wreckage, 15 ft above the mineral substratum. As the pile of logs decays away, it is expected that the trees will be tilted one way or another until their root crowns come to rest on the forest floor. A line of tilted living hemlocks should eventually mark the line of the forest wreckage. (4) Detailed study of the new forest grown on the 1958 wave-denuded bench on mainland due south of Cenotaph Island revealed a dense stand of tree alders (*Alnus oregona*) already grown 40 ft tall and 5.5 inches dbh from seed in 15 yrs. Many shrub alders (*Alnus crispa sinuata*) also established from seed, probably at the same time, in the spring following the Giant Wave of 1958, had died because of competitive shading by the tree alders. In some places there was a vigorous understory of Sitka spruces up to 8 ft tall. (5) Along the beach lichens, many with disc-shaped bodies, grown on a horizontal log deposited just above high tide level by the 1958 Giant Wave, were photographed and collected in duplicate. These have been identified by Dr. Clifford Wetmore, Department of Botany, University of Minnesota. One set will be contributed to the Glacier Bay Herbarium at Bartlett Cove; the other will be retained in the Herbarium of the Department of Botany, University of Minnesota, St. Paul, MN 55101.

**RECOMMENDATIONS:** It is obvious from the present observations that detailed studies of the vegetation development process employing permanent plots at various places along the slopes of the bay denuded by the Giant Wave of 1958 should have been initiated immediately after that catastrophic event. Observations made then and annually thereafter would have revealed the relative importance of vegetative regrowth from undestroyed remnants of old plants versus establishment of young plants from seeds and spores buried in the soil and/or dispersed from adjacent undisturbed vegetation. If another giant wave occurs, high priority should be given to such studies. In view of the evidence that giant waves in the past have occurred at intervals of about 20 to 60 years since 1953-54, it would seem probable that other giant waves will occur in the future. It would be provident, therefore, to prepare in advance a comprehensive research plan so that when the next episode occurs, a well-organized study can be begun at once.

GEBOTANICAL RECONNAISSANCE AT LITUYA BAY, ALASKA  
GLBA-N-9

INVESTIGATOR: Edward J. Cushing  
University of Minnesota

SUMMARY OF PROGRESS: This 6-day reconnaissance of the vegetation, glacial geology, and paleoecology of the Lituya Bay area focused on the following aspects:  
(1) Familiarization with flora. About 100 vascular plants were identified and recorded; of these, voucher specimens were collected of 49, especially those from which pollen was collected. These will be deposited in the Herbarium, University of Minnesota. (2) Pollen reference samples were collected of 34 species to aid in the identification of fossil pollen grains. (3) Description of vegetation, based on field notes and photographs. Relevés were made in three community types in which surface samples of pollen were collected. (4) Present pollen assemblages. Samples of surface sediment or litter were collected at four sites for comparison of the pollen assemblage with vegetation and for study of the variability of preservation in various substrates. (5) A stratigraphic sequence of samples for pollen and macrofossil analysis was collected in sections of a kame terrace of presumed Neoglacial age on Solomon Railroad. Analysis of these samples and comparison with the surface samples should suggest whether the Neoglacial advance in Lituya Bay was accompanied by marked change in the vegetation beyond the glacier margin.

Analysis of the samples collected is in progress.

RECOMMENDATIONS: (1) A promising extension of the reconnaissance would be to investigate the vegetation and pollen stratigraphy of the higher marine terraces north of Lituya Bay, reputed to be unglaciated. Refinement of the pioneer pollen analysis by Heusser, including statistical comparison with an increased number of surface samples, should test the hypothesis that the forest communities have remained distinct and stable during most of the Holocene. (2) The area of stagnant Neoglacial ice north of Fish Lake provides a stimulating analog to the reconstructed landscape of much of central North America, e.g., Minnesota, during Late Wisconsinan time. Investigation of the sediments and buried soils in the still-forming kettles of the Fish Lake area should yield insight into the origin of similar features that are common in Minnesota.

# # #

BIOCHEMICAL PATTERNS IN PLANTS OF THE SUCCESSIONAL DEVELOPMENT IN  
THE DEGLACIATED AREA OF GLACIER BAY MONUMENT, ALASKA  
GLBA-N-9

INVESTIGATOR: Pei-Hsing Lin Wu  
Ohio State University

SUMMARY OF PROGRESS: Further efforts are needed to complete testing on plants in all three plant successional communities which have not been studied. I estimate that it will take 2 additional summers for the field work and 2 academic years for laboratory work.

RAISED MARINE TERRACES SOUTHEAST OF LITUYA BAY, ALASKA  
GLBA-N-11

INVESTIGATOR: Stephen Jay Derksen  
Ohio State University

SUMMARY OF PROGRESS: Mechanical, heavy mineral, scanning electron microscope and micro-paleontological studies of sediments overlying the five major terraces occurring between elevations of 25-1700 ft indicate that the lower four have definite indications of a marine origin while the highest surface, though morphologically similar, does not. Preliminary palynological investigation of a peat sequence overlying bedrock on this highest terrace indicates peat accumulation began no earlier than Hypsithermal time.

Earlier workers have attributed the formation of the marine terraces and sea cliffs which back them to higher interglacial sea-levels in a region of slow tectonic uplift. However, current research indicates a maximum age for the lowest terrace and sea cliff of about 400 years. Thus, discontinuous periods of rapid tectonic uplift may have had more significance for the formation of these raised terraces than previously recognized, strongly affecting their relationship to the interpretation of the glacial history of this region.

However, progress thus far indicates the third-highest terrace was cut in pre-Wisconsinan time, and the highest terrace of known marine origin was cut before glacial moraines were deposited on it, probably in pre-Illinoian time. Therefore, part of this area may have been ice-free for at least the past 120,000 years.

When laboratory investigations are completed this spring, radiocarbon dates of basal peat and wood, palynological data from peat sequences overlying the higher terraces, and relationships between marine terraces and glacial deposits of known age should bracket the times of terrace formation considerably more accurately, clarifying the glacial history of this region.

# # #

FOLLOW-UP ON SEA OTTER REINTRODUCTION  
GLBA-N-12

INVESTIGATOR: G. P. Streveler

OBJECTIVES: To document the distribution and abundance of sea otters which were reintroduced into Glacier Bay National Monument in July 1968.

METHODS: Periodic spot checks along the monument's lower outer coast by plane and boat.

RESULTS AND DISCUSSION: A major survey in 1972 failed to produce sea otter sightings, despite extremely favorable sea and weather conditions. This result, coupled with reason to suspect that the transplanted otters have moved a short distance south of the monument boundary, led to deemphasis of the survey effort in 1973.

No otters were seen on an all-day dory trip in the Dixon Harbor area. Two aerial overflights of inshore waters between Cape Spencer and Icy Point also produced negative results.

HARBOR SEAL MOVEMENTS, BEHAVIOR, ABUNDANCE  
GLBA-N-13

INVESTIGATOR: G. P. Streveler

OBJECTIVES: To devise a census technique capable of detecting seasonal and annual changes in the abundance of Glacier Bay seals; to determine the impact of human intrusion into the Muir Inlet seal pupping area.

METHODS: A system involving coordinated land-based and aerial photographic counts is being field tested at Muir Inlet during the pupping season. Once successful there, it will be applied to other pupping areas within Glacier Bay in order to obtain summer population estimates. Censuses via boat, taken yearly, are providing comparative winter data. Observations on seal population structure, pupping behavior, inter- and intra-specific relationships, and response to boat and plane intrusion are made each year at Muir Inlet.

RESULTS AND DISCUSSION: Very satisfactory seal counts obtained from the ground this summer indicate the presence of at least 1600 individuals in upper Muir Inlet. Ground counts now form an adequate control for judging the accuracy of photographic censuses. Technical photographic problems due to the extreme contrast between seals and icebergs on which they rest are apparently close to solution.

A minimum of 450 pups was born in Muir Inlet in 1973. Pups constituted about 30% of the Muir population. No predation on seals was observed or suspected, reinforcing earlier conclusions that killer whales are not significant predators in the pupping area, and that bird interest in seals stems from the opportunity to scavenge afterbirths. Advances in field sexing techniques allowed the first estimation of the sex ratio within nonpupping Muir Inlet seals: 59 males and 44 females out of 103 individuals.

Observation of boat and plane intrusion into the pupping area tended to substantiate earlier suggestions that: (1) overflights are ignored by seals unless the plane actually "buzzes" them; and (2) response to boats varies complexly, apparently as a function of boat speed, passenger activity, mode of approach, and tolerance levels of individual seals.

The great majority of seals on an average day in the pupping area is sheltered from boat intrusion by dense pack ice. However, the portion of the herd at pack ice fringes contains a high percentage of females with pups. Disturbance of mother/pup pairs did not result in any observed mortality this year though the potential for mortality due to separation of the pair seems high.

Recently, there have been attempts to distinguish two species of Alaskan harbor seals: *Phoca largha*, ice-pupping populations in the Bering Sea; and *P. vitulina*, land-pupping populations of generally more southerly distribution. Though Glacier Bay seals pup almost exclusively on ice, their reproductive biology seems quite distinct from the Bering Sea taxon.

PLANS FOR 1974: At least 2 weeks will be spent at Muir Inlet during June. Techniques for aerial photography of seals will continue to be developed. A seal count by boat will be made in February.

INTERTIDAL BIOTA: COMPOSITION AND SUCCESSIONAL PATTERNS  
GLBA-N-16

INVESTIGATOR: George Mueller  
University of Alaska

SUMMARY OF PROGRESS: No field work was carried out this year. However, George Mueller ( U. of Alaska) submitted a written summary of past findings and has provided us with a series of specimens representing nearly all species he has collected.

# # #

THE BREEDING ECOLOGY OF COLONIAL SEA BIRDS ON THE MARBLE ISLANDS  
OF GLACIER BAY, ALASKA  
GLBA-N-16

INVESTIGATORS: A. R. Weisbrod )  
Samuel M. Patten, Jr.) University of Washington

OBJECTIVES: To carry out intensive investigations of marine bird colonies on North and South Marble islands, the largest in bay waters, Glacier Bay National Monument, during this second and final season of field work.

SUMMARY OF PROGRESS: (1) Bird migration was observed; a log of species and of their date of occurrence was maintained. (2) A sample of 100 gull nests from three different colonies was analyzed to determine percentage by weight of the various plant components and to attempt to determine the impact of gull nest construction on island vegetation. (3) In six gull colonies 380 additional nest sites were located, tagged with survey markers and flagging tape, and numbered consecutively. These sites were visited regularly through the summer, and following the reproductive activity at these sites formed the bulk of the summer's study. (4) Six active Black Oystercatcher nest sites were studied throughout the season. The sites were located and marked in the same fashion as the gull nest sites. (5) Approximately 30 Pelagic Cormorant nests were located on the cliffs on the perimeter of North Marble Island. Reproduction was assessed qualitatively. (6) Several Black Guillemot nests were located in rock crevices above the high tide line, and some information was obtained on egg and chick weights. (7) Vegetation species composition was analyzed by means of Daubenmeier plots. Intertidal fauna was analyzed in a similar fashion. (8) Supporting information was gathered from South Marble and several other islands.

SIGNIFICANT FINDINGS: (1) Approximately 50 bird species were recorded on or near the Marble Islands during the spring and summer. (2) Approximately a ton of vegetation, mostly mosses, grasses, and fireweed stems, is used by the approximately 500 pairs of gulls on North Marble for nest construction. (3) Gull reproduction was very good this season, with an average of 1.75 chicks fledged per clutch of three. (4) Black Oystercatcher reproduction was good, with an average of about one chick fledged per clutch of an average slightly over two eggs. (5) Cormorant reproduction in 1973 was noted to be good; two or three eggs were laid per nest; two or three nearly fledged chicks were seen per nest site at the close of the season. There was a sharp increase in the number of cormorant nests located this year; more cormorants appeared to be breeding. (6) Information is available on the numbers of guillemots and puffins breeding on the Marble Islands. (7) Meadows used by gulls as nesting colonies show a different plant species composition and a lower number of species, possibly due to trampling and fertilizing by gulls. Mussels (*Mytilus*) are the most common macroorganism in the intertidal and are the most abundant food remains recovered from

gull middens on the island. Gulls, however, appeared omnivorous from hard parts of food remains. (8) Approximately 250 pairs of gulls bred on South Marble Island. Reproduction was judged to be good.

Marine bird colonies within monument boundaries should be closed to public access during the breeding season. A literature review indicates marine bird reproduction is inversely proportional to the amount of disturbance.

# # #

#### VARIATIONS IN GLACIER TERMINI GLBA-N-6a

INVESTIGATORS: W. O. Field) American Geographic Society  
Austin Post) U.S. Geological Survey

SUMMARY OF PROGRESS: Austin Post made an especially complete series of aerial photographs of the Brady Glacier's southwestern fringes including the area that may be disrupted by Newmont Mining.

He also made a bathymetric survey of Lituya Bay. This data will be compared with earlier bathymetry, which will allow calculation of volumes and distribution of sediments from the earthquake and resultant wave of 1958.

# # #

#### PRELIMINARY BIOLOGICAL INVESTIGATIONS OF THE LITUYA BAY ICE-FREE REGIONS GLBA-N-17

INVESTIGATOR: A. R. Weisbrod  
University of Washington

SUMMARY OF PROGRESS: The second field trip into the Echo Creek drainage, 10 km NW of Lituya Bay (50°42'N, 137°40'W), was undertaken 19-28 June 1973. A base camp at 255 m elevation was established at the edge of a heath-dominated muskeg in the spruce-hemlock-cedar forest common to the area. Snow depths at higher elevations prevented work above 300 m. Habitat data were obtained from 43, 1 m<sup>2</sup> plots along four vegetation transects in the forest and muskeg. Twenty-two species of birds were recorded for the area including a pair of three-toed woodpeckers. One species of fish (*Salvelinus malma*) was found inhabiting Echo Creek at about 200 m elevation, 4+ km east of the coast. Thirty-two *Clethrionomys* sp., four *Microtus longicaudus*, five *Sorex* sp., and five *Tamiasciurus hudsonicus* were collected in 770 trap nights.

SIGNIFICANT FINDINGS: Both the bird and small mammal populations and species composition appear to be noticeably different from those sampled at Thistle Cove (3-28 July 1973). The significance and implications of these differences cannot be ascertained until further sampling is conducted both north and south of the Lituya Bay areas.

RECOMMENDATION: It is strongly recommended this study be conducted in close cooperation with the Thistle Cove Impact projects thereby obtaining comparative regional data for both studies and providing accurate information about the Lituya Bay area prior to active mining operations by Titanium Gold Placers, Inc., which are planned to begin in the near future.

SURVEY OF THE BIOTA AND ECOSYSTEMS OF GLACIER BAY NATIONAL MONUMENT  
GLBA-N-19

INVESTIGATORS: R. Gordon                    I. Worley                    )  
                  C. Terry                    G. P. Streveler)     Monument Field Staff

OBJECTIVES:     In general, to construct a "before" picture of the monument's biota and ecosystems against which man-induced changes can be measured. In particular this year, to begin an ecological assessment of an area along the monument's outer coast that may be disrupted in the near future by mining activity.

METHODS:        Outer coast research this year was divided as follows: preliminary floral and vegetational analysis (Worley & Streveler); bird survey (Gordon); small mammal survey (Terry); large mammal survey (Streveler). Each investigator employed standard field techniques that will not be detailed here. Nearly all research was accomplished during mid-summer.

RESULTS AND CONCLUSIONS:     As usual, a wide variety of observations were recorded this year. Emphasis was placed on organization of the voluminous bird record file. A summary of the results of outer coast research follows.

The study area's flora is generally a typical northern southeast Alaskan one. However, the alpine apparently lacks a number of expected meadow and tundra species; lush low-alpine habitats, often extensive elsewhere, are unusually restricted and depauperate. A wide range of lowland communities exist.

Resident birds seem sparse in most habitats.

Shrews and microtines were abundant in most lowland habitats during this, a "high" year for the monument's small mammals. *Sorex obscurus*, *Microtus logicaudus*, and *Clethrionomys rutilus* occurred together in many habitats; *Microtus oeconomus* was encountered uncommonly in meadows and marshes.

Ten species of larger mammals are known to inhabit the study area. A scarcity of canid species may in part explain the observed abundance of medium-sized mustelids. Black and brown bears are common. At least four wolves range the area; their diet includes goat, over 90 of which were observed in upland habitats. Certain expected species--moose, fox, wolverine--have not yet been noted.

PLANS FOR 1974:     The results of this year's work are to form the basis for a proposal requesting funding for a broader, more intensive research effort next summer.

# GLACIER NATIONAL PARK, MONTANA

## ENTOMOLOGICAL STUDIES IN GLACIER NATIONAL PARK

INVESTIGATOR: J. Gordon Edwards  
California State University

OBJECTIVES: To observe, study, collect, and identify insects in Glacier National Park, especially those occurring above tree line. To determine the major ecological influences in the high altitude habitats of the northern Rock Mountains. To categorize the environmental effects of the various kinds of insects, by noting which ones are predators, which are parasites, which are leaf-eaters, which are scavengers, and so forth.

METHODS: Daily investigative trips were taken, and considerable night-time collecting was also done to supplement the diurnal observations. Insects were collected with aerial nets, with dip nets (in ponds and streams), with insect traps, and by visual inspection of habitats. Insects were obtained in large numbers from flowers and foliage, from beneath rocks and logs, from snowbanks and snowfields (and glacier surfaces), and from the vicinity of electric lights at night.

Specimens were killed in cyanide jars or in 80% ethyl alcohol or in KAAD (a mixture specifically for killing caterpillars and other kinds of insect larvae). The specimens were labeled with field numbers to correspond with numbers in field books recording behavioral and ecological observations, then were stored in dry envelopes or in alcohol vials or in ethyl acetate containers. (Facilities were not available for microscopic examination of the specimens or for mounting, labeling, or identifying insects while doing research in the Swiftcurrent area.)

After returning to San Jose, I relaxed the specimens and curated them. Because dried specimens are much more difficult to restore to workable conditions than are fresh specimens, I must spend dozens of hours on the curation of specimens brought back from Montana. This occupies much time in September, October, and November. The specimens must then be labeled and sorted, after which they are ready for identification.

Although I am proficient in identification of insects at the Order and Family level, and have specialized in the taxonomy of Coleoptera for more than 30 years, it is necessary for me to send other groups of specimens away for reliable identification. Fortunately, I have colleagues and friends throughout the United States who are specialists in those other groups of insects, and they identify the specimens I send for their determinations. The result is an increasingly valuable collection of insects from Glacier National Park, which is available for the use of any professional entomologists who wish to study it.

RESULTS AND DISCUSSION: Numerous new records and valuable ecological observations result from each summer of field research in the mountains of western United States. Comparisons must be made between the faunal elements of the various western ranges of mountains, as well as between the high altitude biomes and those of the nearby valleys and prairies. On an even broader scale, I have compared the western mountain insect fauna with that of eastern mountains, with the mountains of Central America, and with the Alaskan insect fauna. Future research ambitions include similar investigations in South America, Africa, the South Pacific island, and Canada's "High Arctic" regions.

The specimens collected and observed in 1973 have been compared with those obtained during the previous 23 summers, during which I devoted several weeks each year to this continuing study. The intense heat of 1971 caused interesting deviations from normal in the insects of Glacier National Park, and now the extreme drought conditions of 1973 have provided excellent opportunities to compare the effects of heat alone with those

of drought alone in those northern mountains. The most obvious result was that the heat had a far greater effect than did the drought, almost entirely driving the insects away from mountain summits and forcing them down to the very floors of the valleys where they would never have been found otherwise (in 1971). Although the drought was a severe factor for mammals and smaller vertebrates, it did not appear to adversely influence the insects. They were still common at or near the mountain summits, when wind factors were not too severe, and they were apparently not forced down into the valleys by the drought of 1973.

The specimens collected in Glacier National Park through the years since 1947 have been very carefully compared with those I collected in the mountains of all other western states and provinces, including Alaska, Yukon Territory, and the Northwest Territory of Canada. There are countless interesting similarities of interest to entomologists, as well as puzzling differences. Many of these observations have been publicized already, and others will provide a basis for future articles.

It is only through conscientious, long-term field studies of this sort that one can become so familiar with the alpine environment that he will sense what is significant (and what is not) when he enters any alpine habitat in new ranges, new massifs, or continents new to him. As a result of his thorough familiarity with one or more of these alpine habitats, he should be able to understand and explain the unique features of other alpine habitats, even after relatively brief studies.

#### Publications:

(All of the following publications are by J. Gordon Edwards.)

1949. Coleoptera or Beetles East of the Great Plains. 181 p., 539 illus., 8½ x 11, cloth. Ann Arbor, Mich.
1950. Western Supplement to above, with Bibliographical Supplement added. 30 p, 8½ x 11, paper.
1950. Amphizoidae of the World. *Wasmann J. Biol.* 8:303-332. (Three species are in Glacier N.P.)
1951. Cupesid beetles attracted to soap in Montana. *Coleopterists' Bull.* 5:42-43. (Lk. McDonald, Glacier N.P.)
1953. The real source of *Amphizoa* secretions. *Coleopterists' Bull.* 7:4-5. (Observations from Glacier N.P.)
1953. Species of the genus *Syneta* of the World. *Wasmann J. Biol.* 11:23-82, 47 illus. (Several species were from Glacier N.P.)
1953. The peculiar clasping mechanisms of the phallus of males of *Priacma*. *Coleopterists' Bull.* 7(3):17-20. (Based on specimens mentioned in 1951 article, above.)
1953. The morphology of the male terminalia of *Priacma*. *Inst. Royal des Sciences Naturelles de Belgique, Bull.* 20, No. 28:1-8, 8 illus. (Based on specimens from G.N.P.)
1954. Observations on the biology of Amphizoidae. *Coleopterists' Bull.* 8:12-24. (Study made at Swiftcurrent R.S., G.N.P.)
1954. A note on the eggs and larvae of *Amphizoa*. (First eggs ever found) *Pan-Pacific Entomologist* 30: p. 86. (G.N.P.)
1956. Entomology above timberline. *Mazama Annual* 38:13-17.
1957. Some general observations on the ecology of Glacier National Park, with special reference to certain entomological aspects. *Wasmann J. Biol.* 15:123-151, 5 photographs.
1957. The Ptarmigan of Glacier National Park, Montana. *Audobon Magazine* Nov-Dec 1957, p. 252-255, 5 photographs.
1957. Congregations of ladybird beetles on mountain-tops. *Coleopterists' Bull.* 12:41-46.
1958. Along the trail, in Glacier National Park. *Minnesota Naturalist* 9(2):18-22, 4 photographs.
1958. Climbing Glacier's Massive Peaks. *Minnesota Naturalist* 9:44-47, 4 photographs.
1959. Ptarmigan of Glacier National Park, Montana, in *Best Animal Stories* from Audobon: p. 210-215. Crowell Co.
1960. A Climber's Guide to Glacier National Park, Montana. 141 p., 55 photographs, 9 maps. 5 x 7 cloth. Sierra Club publication, San Francisco.

1960. Alpine insects of the Teton Range (Wyoming). Rept. of Jackson Hole Biological Research Station, 1960, p. 10-12.
1961. Alpine entomology. Rept. Jackson Hole Bio. Res. Sta., p. 6-9.
1963. Ecology, taxonomy and bionomics of insects in the Grand Teton area of Wyoming. Rept. Jackson Hole Bio. Res. Sta., p. 7-9.
1963. Ptarmigan, or alpine grouse, in Montana. *Audobon Encyclopedia* (3 pages).
1965. Birds of Glacier National Park, Montana. (Chapter in *The Bird Watcher's America*, by Pettingill, p. 124-132.) McGraw-Hill, New York.
- 1964-1972. More than a dozen articles published in *The Mountain Ear (J. of Rocky Mountaineers, of Missoula, Montana)*.
1967. A Climber's Guide to Glacier National Park, Montana. (Second Ed., 165 p., 55 photos, 9 maps, 26 drawings) Published by Sierra Club, San Francisco.
1971. Biological research opportunities in Glacier Bay National Monument, Alaska. San Jose State Univ., Research Repts. 12 p.
1973. Carabidae of Glacier National Park, Montana. *Coleopterists' Bull.* (in press)
1973. Cerambycidae of Glacier National Park, Montana. (MS form)
1956. Photographs in Many Splendored Glacierland (*National Geographic*, May 1956).
1963. Photographs in *The American Heritage Book of Natural Wonders*. (Glacier National Park and Teton National Park).
1969. Photographs in *Sprung ins Leben* (Switzerland).

Note: The publications on Amphizoidae, *Amphizoa*, Cupesidae, *Priacma*, and Ladybugs were all done during the course of this research in Glacier National Park. The articles on *Syneta*, Carabidae, and Cerambycidae were based on specimens from Glacier National Park but were written after returning to San Jose. The Climber's Guides and Climbing Routes were based on research assignments and lieu day activities from 1947-56, and research as biological collaborator from 1958-72 (still in progress).

# # #

#### 1973 PROGRESS REPORT STONEFLY (PLECOPTERA) ECOLOGY STUDIES IN GLACIER NATIONAL PARK

INVESTIGATOR: Arden R. Gaufin  
University of Utah and University of Montana

OBJECTIVES: To determine the species, distribution, biogeographical relationships, life histories, and ecological requirements of stoneflies (Plecoptera) in Glacier National Park.

METHODS: Nymphs and adults of stoneflies from various lakes and streams in the park have been collected particularly during the summer months (June through August) since 1963. Quantitative samples using a hand screen and/or square-foot sampler have been taken particularly from the Swiftcurrent Creek and Camas Creek drainages to determine the relative abundance of immature stoneflies in these streams. Adults have been collected by sweep nets, turning over rocks, and can traps to determine species distribution, dates of emergence, and life cycles. Analyses of the water in selected lakes and streams for dissolved oxygen, pH, CO<sub>2</sub>, carbonate alkalinity, and temperature have been conducted during several summers to determine ranges of these ecological factors. Currently a year-round intensive study of the North, Middle, and South Forks of the Flathead River extending to the Flathead River at the junction with Flathead Lake is in progress.

RESULTS AND DISCUSSION: A total of 73 species of stoneflies has been collected from the park since 1963. This compares favorably with the 119 species that have been collected from the entire state of Montana and which were listed in *The Stoneflies (Plecoptera) of Montana*. 1972 *Trans. Am. Entomol. Soc.* 98:1-161.

With the great variety of habitats found in the park, nymphs have been collected in seeps, springs, small and large streams, the Flathead and St. Mary's River, and small

to large lakes. One species (*Capnia spenceri*) representative of a genus which normally emerges only during the winter months was collected from Iceberg Lake during late July and August. The temperature of the lake at that time of the year rarely exceeds 34°F. Several species have been found restricted to precipitous streams and waterfalls, while others particularly belonging to the family Nemouridae have been found only in seeps and springs along the edges of lakes and in small, slow-moving streams.

Emerging adults belonging to one or several of the 10 families or subfamilies of Plecoptera have been taken at all seasons of the year. Several species such as *Alloperla pallidula* have been collected emerging from both lakes and streams throughout the summer months, while others such as several species of *Capnia* have been collected for only a few days during the winter season.

The distribution of species in the park is decidedly influenced by the stream drainage pattern and mountain ranges. Several species of Pacific Coast stoneflies have been found restricted to streams on the west side of the park, while several other species that range eastward to the plains of Montana have been collected only from streams constituting the Missouri River drainage.

Of the various ecological factors investigated, temperature, substrate, and stream velocity have been found to have the most important effects on stonefly distribution. The decided seasonal variation in the numerous types of habitats found in the park has been found to be particularly important in its effect on the growth rate, seasonal emergence, and distribution of many of the species which occur.

Publications:

Gaufin, A. R., W. E. Ricker, M. Miner, P. Milam, and R. A. Hays. 1972. The stoneflies (Plecoptera) of Montana. *Trans. Am. Entomol. Soc.* 98:1-161.

# # #

A SYSTEMATIC STUDY OF *SMELOWSKIA CALYCINA* (CRUCIFERAE) IN NORTH AMERICA

INVESTIGATOR: Craig W. Greene  
University of Alberta

OBJECTIVES: To determine the ranges of diploid ( $2n = 12$ ) and tetraploid ( $2n = 22$ ) chromosome races of the alpine mustard (*Smelowskia calycina*) in North America and to relate this data to the effect of the Pleistocene glaciations on their distributions.

METHODS: Both living and preserved collections of *Smelowskia calycina* were made from throughout the range of the species from Colorado to Alberta in the Rocky Mountains and in Alaska and the Yukon. Chromosome counts were made from root tips of the live material grown in an experimental greenhouse. Several representative populations were examined chemically and morphologically to determine range of variation within the species. (This work was undertaken as an M.Sc. Thesis project in plant systematics at the University of Alberta.)

RESULTS AND DISCUSSION: The diploid populations were found to be present in the southern Rockies north to the Swan Range in Montana. All populations sampled in Glacier National Park and further north in Alberta, Alaska, and the Yukon were tetraploid derivatives of the diploids. Morphologically, the two races are indistinguishable.

The presence of two distinct chromosome races of *Smelowskia calycina* in North America suggests that the present distribution of these is the result of two distinct interglacial migrations and not one as has been previously suggested (Hulten 1937; Drury and Rollins 1952).

I am proposing that the first migration established diploid populations from the Altai Mountains of Asia in a continuous band across the Bering land bridge and south along the North American Cordillera to southern Colorado. The only diploids remaining are in the southern Rockies and in the mountains of temperate Asia; all northern populations were exterminated by the glaciation that followed. During the succeeding interglacial period, a tetraploid form arose and migrated northward to the Arctic to form a continuous range joining the diploids in Asia and North America. These tetraploids now remain only where they survived the Wisconsin glaciation, i.e., in the vast refugial area of northern Alaska and the Yukon, on scattered mountains from 50° to 54° north latitude in Alberta, and on most of the mountains around the Glacier-Waterton Park area. These populations supposedly have survived *in situ* and have not migrated from the localities where they survived the last glaciation. This distribution pattern in the northern Rockies is evidence that there were substantial areas in the mountains north of the 49th parallel that remained ice-free during the Wisconsin glaciation. The diploid populations, by the same token, have survived two separate glaciations where their populations now persist in the southern Rockies.

References:

- Drury, W. H., and R. C. Rollins. 1952. The North American Representatives of *Smelowskia* (Cruciferae). *Rhodora* 54:85-119.
- Greene, C. W. 1974. A systematic study of *Smelowskia calycina* in North America. M.Sc. Thesis, University of Alberta.
- Hulten, E. 1937. Outline of the history of Arctic and Boreal biota during the Quarternary Period. Stockholm, 168 p + 43 pl.

# # #

THRUST FAULT STUDIES IN GLACIER NATIONAL PARK

INVESTIGATOR: Paul V. Smith  
Johns Hopkins University

OBJECTIVES: To obtain data on the orientation, magnitudes, and interrelationships of strain features in the shear zone (i.e., near the fault contact) of the Lewis Thrust.

METHODS: Measurements of orientations of large and small folds and faults, bedding, slickensides, mineral-filled fractures, and stylolites were taken in the field with Brunton Compasses. Oriented samples were also taken and sawed up for examination of fine details in thin section and with binocular microscope. Photographs and sketches of significant features were also made in field.

RESULTS AND DISCUSSION: During the summer of 1973, I spent several weeks in Glacier National Park, at several localities, particularly Summit and Chief Mountains. I also visited thrust fault exposures in other parts of Montana, Alberta, and British Columbia, and am carrying on work in the Appalachians.

On my first trip west I was just getting acquainted with the rocks involved in thrusting--I took notes and photos of folds, faults, etc., measured orientations of deformation features, took oriented samples, but not in any great detail in any one spot.

After returning to Baltimore, I cut up many of my samples, made thin sections and stained slabs, and found a variety of small-scale strain features not visible on the weathered surfaces. Stylolites, extension veins, micro and minor faults, and dolomitized breccia zones occur in complex systems near the thrust contacts and appear to be related to the motion, giving a measure of the deformation history of the rocks which can be correlated with theories of thrust mechanics.

I plan to continue working, now in more detail, at a few good exposures, like at Summit Mountain, to establish characteristic strain profiles--i.e., stratigraphic column--like cross sections of all deformation features in the shear zone. This will require careful study and lots of measurements in the field, plus gathering samples to work on in the laboratory.

I will be working, at least qualitatively, to establish the type of strain and mechanical conditions associated with thrusting, plus velocity profiles and, if possible, strain values, which are necessary before one can decide which of the proposed theories of sliding of thrust sheets are correct.

PLANS FOR 1974: Will visit many localities in the Appalachians during the spring, and go to Montana to revisit Summit Mountain and other spots during the summer.

# # #

### SEARCH FOR BURROWS OF PRECAMBRIAN METAZOA IN GLACIER NATIONAL PARK

INVESTIGATOR: Charles W. Thayer  
University of Pennsylvania

OBJECTIVES: It is likely that metazoa originated in "oxygen oases" adjacent to stromatolites. The present project examines sediments adjacent to Precambrian stromatolites for burrows produced by metazoa.

METHODS: Each of the stromatolite zones of Rezak (1957, U.S. Geol. Surv. Prof. Pap. 294-D) will be sampled. The search for burrows will be made via sections cut perpendicular to the bedding, thereby permitting burrows to be distinguished from deceptively similar bedding plane features (e.g., mud-cracks).

RESULTS AND DISCUSSION: In 1973, four of the eight algal zones were sampled. Specimens will be sectioned and studied during the spring of 1974.

# # #

### EFFECT OF PENTACHLOROPHENOL-TREATED LUMBER ON ALPINE ECOLOGY

INVESTIGATORS: Gary Beaver )  
Patricia Meinhardt) Eastern Montana College

OBJECTIVES: To obtain qualitative and quantitative data on the effects of pentachlorophenol on alpine fir, other associated plant species, native animal species, and general impact on the ecology of the subalpine area of Logan Pass.

METHODS: The chemical damaging alpine fir trees growing near the wooden walkway on Logan Pass was identified by bioassay techniques under greenhouse conditions. Young alpine fir and grand fir were subjected to volatile fractions of the wood preservative under isolation hoods. Gas chromatographic techniques were used to confirm the bioassay results.

Data on the growth of alpine fir trees were obtained by measuring the yearly growth increment at the tips of branches at random locations on two sides of the tree

representing three verticle sections. The degree of chlorosis and/or necrosis of the foliage was also recorded in relation to distance from wooden walkway.

Soil samples were collected from undisturbed areas and areas near and under lumber stacks and wood walkways. These samples were assayed and compared for the presence of microorganisms. Detailed visual comparisons were made between plant species in the area of the walkway and in undisturbed areas.

Statistical analysis are currently being run on these data to determine spread and extent of damage to plant and microorganisms in the area of the wooden walkway.

RESULTS AND DISCUSSION: Volatilizing pentachlorophenol was confirmed as the agent damaging alpine fir and other vegetation adjacent to the wooden walkway. The extent of damage appears to be dependent upon the distance of the plant from the walkway and the direction of wind current in the area. The sides of trees away from the walkway appeared to be less damaged than adjacent sides. Severity of damage was also dependent on wind currents and distance from the walkway. This data is currently being reanalyzed in light of new statistical techniques.

Broadleaf vegetation was affected within 1 m of the walkway but no visible damage occurred at greater distances. Damage within the 1-m area was typical of herbicidal action. Plants located beneath walkways were killed or severely burned where the penta-oil mixture bled onto them from the boards above. This penta-oil mixture was also carried in the run-off water for many yards below the walkway. Foot traffic was also effective in spreading the oil mixture from the walkway up and down the soil footpath at the ends of the walkway. Traces of the penta-oil mixture could be seen for hundreds of feet along the soil trail where it also collected in pools of run-off water.

The effects of the penta-oil mixture on soil microorganisms in areas adjacent to the walkway is currently being determined. Initial tests were inconclusive and are being rerun.

Replacement of treated planking with nontreated lumber on the treated understructure failed to stop damage to adjacent alpine fir although severity of damage was reduced.

CONCLUSIONS: Data collected to the present time show that alpine fir (*Abies lasiocarpa*) are extremely sensitive to low levels of vapor from penta-treated lumber. These data also suggest that any above-ground construction should be accomplished with nontreated materials. Investigations at this time have not yet revealed the long-range effects of pentachlorophenol on plant and animal life in the subalpine areas of Logan Pass.

Accumulation of toxic levels of penta exuded from treated lumber has not been ruled out and could severely damage, if not eliminate, certain native plant and animal species from the run-off areas. Further still, the distance to which penta may be moved by foot traffic or run-off water is unknown.

Reports from the American Industrial Hygiene Association list skin contact with pentachlorophenol as dangerous and lethal under prolonged contact. This fact alone is sufficient to warrant complete removal of all surface planking on the walkway since many tourists spend prolonged periods standing on the treated lumber with bare feet. Uptake through the skin can occur in as little as 10 minutes with continual contact.

Based on data collected, personal observations, and hazard warnings published on pentachlorophenol, we strongly recommend that use of pentachlorophenol-treated lumber in all above-ground construction be discontinued and that all facilities constructed with penta-treated lumber be removed where contact with the general public is likely.

# # #

## UNGULATE WINTER ECOLOGY STUDIES IN GLACIER NATIONAL PARK

INVESTIGATOR: C. J. Martinka  
National Park Service

METHODS: Population parameters and ecological relationships of wintering ungulates were studied by recording standard sighting data during routine observation trips to winter ranges. Food habits were determined from feeding site evaluations and habitat impact from measurements of forage utilization and growth form.

RESULTS AND DISCUSSION: Monitoring of elk (*Cervus canadensis*) and mule deer (*Odocoileus hemionus*) populations on the Belton Hills continued. Populations of both species remained relatively stable following the mild winter of 1972-73. Productivity of elk continues to be unresponsive to changes in winter severity, while mule deer response is somewhat greater. Reproductive cores of both populations are relatively invulnerable to winter stress and serve as a deterministic unit of natality and mortality rates. Populations are being regulated by natural factors below the apparent biomass carrying capacity of winter forages. Browse use tends to enhance rather than restrict carrying capacity in apparent response to accelerated nutrient cycling. The two species exhibit significant differences in niche occupancy.

Winter ecology studies were expanded in 1973 to include an initial inventory of the North Apgar winter range which was burned in 1967. Wintering elk were not observed but relatively high densities of mule deer were present. Forage species were abundant and lightly utilized, but mule deer productivity was essentially similar to that on the Belton Hills. The absence of wintering elk suggests a relationship to forest canopy reduction since forage and terrain are quite similar to the Belton Hills.

Samples of mountain maple (*Acer glabrum*) have been secured from six areas of differing ungulate use and wildfire history. Measurements of growth characteristics tentatively suggest that maple is well adapted to heavy browsing and frequent burning.

CONCLUSIONS AND DISCUSSION: Wintering ungulates studied are regulating their own numbers at a level somewhat below biomass carrying capacity of wintering habitats. Social interactions in relation to environmental (climatic) stress and habitat composition apparently forms the nuclear complex of the regulatory process. Niche differentiation in relation to environmental gradients causes predictable patterns of ungulate distribution in time and space.

PLANS FOR 1974: Monitoring of wintering ungulate populations will continue. Computer analyses of data will be initiated.

### Publications:

- Martinka, C. J. 1969. An incidence of mass elk drowning. *J. Mammal.* 50(3):640-641.  
\_\_\_\_\_. 1970. Winter foods of white-tailed deer in Glacier National Park, Montana. *Proc. Annu. Conf. Western Assoc. State Game and Fish Commissioners* 50:410-415.

# # #

## GRIZZLY ECOLOGY STUDIES IN GLACIER NATIONAL PARK

INVESTIGATOR: Clifford J. Martinka  
National Park Service

OBJECTIVES: To obtain quantitative data on the dynamics, ecology, and management of grizzly bears (*Ursus arctos*) in Glacier National Park.

METHODS: Population parameters were monitored through reported and verified sightings of grizzlies by the investigator and other qualified observers. Relationships between grizzlies and park visitors were monitored through documentation of molestations, property damages, and personal injuries.

RESULTS AND DISCUSSION: Cumulative observations of 478 social units (singles, consort pairs, sblings, material groups) were recorded from 1967 through 1973. Density sampling provided a basis for estimating a mean of 4.6 grizzlies per 100 km<sup>2</sup> within the park. Expanded estimates for the total park population average 191, with relatively stable trends over the 7-year study period. Population composition was relatively consistent from year to year. Annual increments averaged 16% but realized recruitment was apparently quite low. Population regulation occurred in hypothesized response to social interaction manifested in subadult dispersal and/or mortality.

Niche requirements were provided by combinations of alpine, coniferous forest, snowslide, shrub, and grassland habitats. Analysis of 340 feces revealed significant trophic links to grasses (*Gramineae*), ungulates (mostly Cervidae), horsetail (*Equisetum* spp.), cowparsnip (*Heracleum lanatum*), and huckleberry (*Vaccinium* spp.). Interrelated seasonal trends occurred in habitat and food use, with niche dimensions reflecting adaptive utilization of the cordilleran complex. Black bears (*Ursus americanus*) were considered an important element which influenced density and habitat use of grizzlies.

Encounters between grizzlies and visitors continued to occur at a low rate in 1973. No human injuries have been inflicted since 1968 and control rates by disposal or transplanting are removing only about one bear per year from the population. Management emphasis on visitor travel restrictions and unnatural food control are primary contributors to the maintenance of low conflict and control rates.

CONCLUSIONS: Research data show that the park population of grizzlies is wild, free-ranging, at carrying capacity, and in minimal conflict with park visitors.

### Publications:

- Martinka, C. J. 1971. Status and management of grizzly bears in Glacier National Park, Montana. *Trans. N.-A. Wildl. Nat. Resour. Conf.* 36:312-322.
- \_\_\_\_\_. 1972. Grizzly bears in national parks. *Pacific Search* 6(8):6-7.
- \_\_\_\_\_. 1974. Preserving the natural status of grizzlies in Glacier National Park. *Wildl. Soc. Bull.* 2(1): (in press).
- \_\_\_\_\_. 1974. Population characteristics of grizzly bears in Glacier National Park, Montana. *J. Mammal.* 55(1): (in press).
- \_\_\_\_\_. 1974. Habitat relationships of grizzly bears in Glacier National Park, Montana. (Unpublished manuscript).
- \_\_\_\_\_. 1974. Ecological role of *Ursus arctos* (Carnivora) in Glacier National Park, Montana. (Unpublished manuscript for 3rd International Bear Conference).

# # #

## LOGAN PASS WOODEN WALKWAY STUDY

INVESTIGATOR: Roberta V. Seibel  
National Park Service

OBJECTIVES: To study the effectiveness of a wooden walkway for permitting foot travel by visitors over an alpine meadow (Hidden Lake Trail) while reducing the ecological impact resulting from indiscriminate foot travel.

METHODS: Data on Logan Pass visitor use were obtained through monitoring programs documenting visitor center use, trail use, and comparative effectiveness of each trail surface for preventing indiscriminate use. Ecological data were obtained from vegetation transects and temperature measurements of each type of trail surface. Markers were placed to determine if and to what degree there is movement of the wooden walkway. The trail and drainage pattern was mapped.

RESULTS AND DISCUSSION: An average of 5200 people per day visit Logan Pass during July and August. This represents about 36% of total park travel and 59% of Going-to-the-Sun Road travel. About 35% (or 1800 daily) of Logan Pass visitors use all or part of the Hidden Lake Trail.

In 1972, 7400 observations of visitor behavior on all types of trail surface showed 8% stepping off the macadam, 13% stepping off the wooden walkway, and 21% stepping off the dirt trail. The 13% figure for the wooden walkway is somewhat misleading due to unusual conditions in July. A more realistic figure for the norm would be the 7% that was observed in August.

In 1973, sampling showed 2% stepping off the wooden walkway and 19% stepping off the dirt trail.

Observations totaling 541 were made to determine reasons for leaving the trail. Leaving the macadam was mainly due to carelessness (41%) or to photograph (23%); leaving the wooden walkway was mainly due to rest stops (46%); leaving the dirt trail was mainly due to shortcutting (45%). The wooden walkway eliminated careless straying because of its raised aspect and eliminated shortcutting because of its construction across the switchbacks.

Random interviews with 650 visitors showed that 72% either prefer or accept a wooden walkway as the alternative to limiting numbers of people on the trail.

With the removal of drainpipes and construction of a raised surface, a more normal drainage pattern was established. Temperature measurements showed that the treated wood portion of the trail had a higher average temperature by 4 to 6 degrees than the other surface types. The generally windy conditions apparently dissipate the heat, for practically no gradient exists. Even though the treated wood acts as a blackbody, it is apparently not significant enough to affect adjacent vegetation.

The wood treatment material (pentachlorophenol) was observed to have an adverse effect (chlorosis) on adjacent subalpine fir. Subsequent testing revealed that the chlorosis was caused by fumigation from the penta and that the effect was reversible upon removal of the source. As a result, that section of walkway through the trees was replaced with untreated wood. All further construction will be with untreated wood.

Some minor structural deficiencies were observed and corrected but did not contribute to esthetic or ecological degradation.

CONCLUSIONS: The evidence thus far substantiates the effectiveness of the wooden walkway in permitting continued foot travel by visitors over the Hidden Lake Trail while reducing the ecological impact currently resulting from uncontrolled foot travel.

PLANS FOR 1974: Due to transfer to another assignment, the author will not be able to continue the study. It is recommended that the study continue for at least three more seasons to observe vegetative response along trail edges and denuded areas.

# # #

## FIRE ECOLOGY AND UNGULATE RELATIONS STUDIES IN THE NORTH FORK VALLEY OF GLACIER NATIONAL PARK

INVESTIGATOR: Francis J. Singer  
University of Idaho

OBJECTIVES: To determine the year and size of the most recent fires, past relative fire sizes, and absolute and relative fire frequencies for the North Fork of the Flathead River. To obtain data on distribution, relative abundance, and habitat relationships of elk, white-tailed deer, and moose, relating habitat use to vegetation types and these in turn to fire incidence and fire sequence.

METHODS: Vegetation types will be determined from (a) aerial black and white photos; (b) aerial infrared color slides; and (c) ground checks. Each vegetation type will be described by sampling plant species for coverage and frequency. Forests will be classified according to the preliminary forest habitat types for western Montana of Pfister et al.

The size and year of the most recent fire will be determined by obtaining a constant age of overstory trees, and from historical records and fire scars. Past fire frequencies and sizes will be estimated from a sample of fire-scarred trees by counting annual rings from the cambium to the scars.

Observations of ungulates and recent (snow) tracks will be obtained from systematic coverage of the study area on foot, skis, and from aerial (fixed-wing) surveys. Plant use will be recorded at recently vacated feeding sites. The habitat preferences of elk, white-tailed deer, and moose will be correlated with vegetation types and with fire history.

RESULTS AND DISCUSSION: Vegetation types have been delimited and described and forest habitat types have been recognized. Sampling of 36 live and dead fire-scarred trees is complete. Data analysis is partial, but does indicate a mean fire frequency of about 28 years in bunchgrass types, mean fire frequency of 105 years in the *Abies/Clintonia uniflora* habitat type, and no fire evidence in Spruce Bottoms and several other mesic types.

Observations of 2100 elk, 700 white-tailed deer, and 47 moose have been recorded. Food habitats have been studied by recording 45,000 instances of plant use at 150 sites. Ungulate studies are in progress and data have not been analyzed.

PLANS FOR 1974: Field studies will be continuous from January through 1 June. Final completion report will also be submitted to the University of Idaho for acceptance as a Master's Thesis. Project and final report will be completed by August.

INVESTIGATOR: Mark L. Fogelsong (UNTITLED)  
Montana State University

OBJECTIVES: To obtain data concerning the effects that observed levels of fluoride, as measured in the femurs of animals, were having on two populations of deer mice (*Peromyscus maniculatus*) in Glacier National Park.

METHODS: Deer mice were trapped from five experimental sites and four control areas in Glacier Park. The experimental sites are regions which are contaminated with excess fluorides from the Anaconda Aluminum Company in Columbia Falls, Montana. Femurs, eye lenses, reproductive tracts (in the case of females), adrenal glands, and body weights were obtained from these individuals. Femurs were analyzed for fluoride content, eye lenses were used to age the animals, and the reproductive data was used to indicate fertility. Qualitative and quantitative vegetation work was completed on each of the collection sites. A laboratory study was conducted in conjunction with the field work. Deer mice in the laboratory were exposed to various levels of fluoride to see what the effects were.

RESULTS AND DISCUSSION: At this time the results are still being analyzed. Preliminary observations of field animals indicate that no damage is being done to the mice's teeth and that reproduction is not being affected. The amount of fluorides in the mouse femurs from the experimental areas average 696 parts per million (ppm). Mice femurs from the control sites averaged 125 ppm of fluoride in femurs. Pregnant or nursing females averaged more fluoride in their femurs than did nonpregnant females. This trend was seen in both the control and experimental sites.

CONCLUSIONS: None at this time.

# # #

#### A MODEL OF THE FORESTS OF GLACIER NATIONAL PARK, MONTANA

INVESTIGATOR: Stephen R. Kessell  
Cornell University

OBJECTIVES: The current research centers on three major areas: (1) Development of the gradient model, including (a) direct habitat gradient analysis along the elevation and topographic-moisture gradients; (b) indirect gradient analysis of low elevation lake influences and high elevation wind-snow-exposure gradients; and (c) determination of primary and secondary succession along additional time gradients. (2) Study of species relationships, including (a) ordination of the component tree (and major herb and shrub) species along these gradients as axes of the habitat hyperspace; (b) study of niche differences (in response to environmental fluctuations by the different species within a stand) for selected communities in the Lake McDonald cedar-hemlock forests and along seven major passes; and (c) preliminary characterization by gross morphology, habitat distributions, and possibly by terpene biochemistry of hybrid *Picea glauca* X *engelmannii*, *Pinus monticola* X *albicaulis*, and suspected *Albies lasiocarpa* X *procera* populations. (3) Application of some of the results, in the form of (a) physical vegetation maps (overlays to the 7.5 minute USGS series) from field samples and the aerial infrared photographs, and a mathematical gradient map--hectare inventory on computer disk; (b) evaluation of the use of the fire succession results for fire management applications; (c) evaluation of current fire suppression policy in Glacier National Park; and (d) development of resource inventory methods, successional models, and wildfire effect programs, which may be combined with fire behavior models developed elsewhere to permit real-time fire simulation.

METHODS: Our field work has included: (1) floristic and environmental descriptions (by field sampling) of 600 communities from within the study area (west of the Continental Divide, from the Canadian border south to and including

the Lincoln drainage); (2) aerial color infrared photography of the study area (covered by about 1200 135 transparencies); and (3) taking increment cores from trees, used for stand dating, recording burn histories, and for niche differentiation analysis within the McDonald forests and along the seven passes.

**RESULTS AND DISCUSSION:** (1) Direct gradient analysis and indirect ordination of field samples reveal the vegetation's response to six environmental complex-gradients-- four are physical (elevation, topographic-moisture, low elevation lake influences, and high elevation snow-wind-exposure), two are temporal (primary and secondary succession). Position of a stand along each gradient allows prediction of its floristic composition using gradient models currently under construction (Kessell 1973 1974c, 1974e).

(2) Species and community relationships along the gradients are being related to macro- and micro-environmental conditions, placing particular attention on natural stresses and limiting factors (Kessell 1974f), periodic perturbations (Kessell 1973, 1974b, 1974c, 1974e), and dominance-diversity-niche division relationships (Kessell 1974d). Niche relationships along the seven passes (Boulder, Brown, Ahern, Swiftcurrent, Hidden, Gunsight, and Lincoln) are being described in terms of macro- and micro-environmental differences, primary and secondary succession, and differential responses to (and selection under) variable meteorological conditions (Kessell 1974f). Similar methods are being used to describe hybridization in *Picea*, *Pinus*, and *Abies*, and for niche analysis in the McDonald forests.

(3) Infrared transparencies are being catalogued, and will be made available to management and scientific interests. A prototype vegetation map has been constructed. The hectare inventory, linked to the gradient models, is being developed on a prototype basis (Kessell 1974c, 1974e).

Application of these results to real-time fire simulation appears to be economically feasible and highly desirable; this work is described in detail elsewhere (Kessell 1974c, 1974e).

A new Checklist of the vascular plants of the park has been completed (Kessell 1974a).

**CONCLUSIONS:** The results of this study, which will be continued with the present objectives through mid-1975, appear to offer new insights into habitat and niche relationships of natural communities, and may provide new management opportunities with the development of resource inventories, successional models, and fire behavior and effects programs. I strongly recommend a thorough evaluation of fire control policy at the conclusion of this study.

**PLANS FOR 1974:** Field work will be completed by October 1974; current research and publication objectives should be reached by mid-1975.

**Publications:**

- Kessell, S. R. 1973. A model for wilderness fire management. *Bull. Ecol. Soc. Am.* 54 (1):17.
- \_\_\_\_\_. 1974a. Checklist of the vascular plants of Glacier National Park, Montana. West Glacier (MT). Glacier Nat. Park Natur. Hist. Assn. 78 p.
- \_\_\_\_\_. 1974b. Wildfires and wilderness fire management. I. Forest fire ecology. In Models as tools for resource management (C. Hall and J. Day, eds.). Kauffman (in press).
- \_\_\_\_\_. 1974c. Wildfires and wilderness fire management. II. Models for fire management. In Models as tools for resource management (C. Hall and J. Day, eds.). Kauffman (in press).
- \_\_\_\_\_. 1974d. Diversity of the forests of Glacier National Park, Montana. Manuscript, for *Ecology*.
- \_\_\_\_\_. 1974e. Wildland inventories and fire modeling by gradient analysis in Glacier National Park, Montana. In prep., invited paper for 1974 Tall Timbers Fire Ecology Conference.
- \_\_\_\_\_. 1974f. Habitat and niche relationships along seven passes in Glacier National Park, Montana. In prep., for *Ecology*.

## QUANTITATIVE EVALUATION OF BACKCOUNTRY USE PATTERNS

INVESTIGATOR: Thomas W. Stuart  
University of California

OBJECTIVES: To develop explanatory models of overnight use in the backcountry of Glacier National Park for the 1973 summer season; and to test hypotheses concerning the influence of various factors on use levels at the designated backcountry campsites.

METHODS: The technique of multiple regression was employed to analyze a combination of cross-section and time series data. The dependent variable was the average number of people camping at a designated backcountry campsite during a half-month period. Seven periods were designated, covering the season from 1 June to 15 September. Data for the dependent variable were obtained from the files in the park's Communication Center, where data are recorded on all backcountry permits issued.

The independent variables consisted of measures pertaining to the physical features of the campsites and their accessibility, the management policies pertaining to the various sites, and weather conditions in the park. These data were collected from topographic maps and from a variety of sources at Park Headquarters.

In addition to collecting data while in the park, the investigator was able to spend time in the backcountry observing visitor use. Nearly 400 miles of trails were hiked and 54 (of the 71) designated backcountry campsites used during the season.

RESULTS AND DISCUSSION: Three models were developed for the 1973 summer season. The first covered the entire season--1 June to 15 September. Models were also developed for those portions of the season having relatively high use. One covered the time period 1 July to 31 August, during which 87.5% of the total recorded overnight backcountry use occurred. The other dealt with the period 16 July to 31 August, which represented 73.8% of the season's use.

The explanatory power of the model for the entire season was reasonably high, with an adjusted  $R^2$  of 0.60. The other two models dealing with the shorter periods of heavy use had higher explanatory power. The model covering the period 1 July to 31 August had an adjusted  $R^2$  of 0.77 and the comparable value for the 16 July to 31 August model was 0.82.

Hypotheses were tested concerning the relation of certain variables to campsite use levels. A number of these variables were significantly different from zero at the 99% confidence level in some, or all, of the models. Significant variables related to such things as the proximity of a campsite to a lake, a chalet, or a trail shelter, the accessibility of the trail head closest to the campsite, the capacity of the site, the weather, the possibility of camping at a site as part of a "loop" trip, and the fishing opportunities at a site.

CONCLUSIONS: The places where people camp in the backcountry (or at least where they indicate they will camp) are far from random. Aggregates of people camping at sites over moderate time periods are reasonably predictable. Careful study of the variables involved in these predictions, both from the present and future studies, should aid in the development of improved backcountry management plans. This will permit definite progress toward the achievement of more desirable use patterns in the backcountry.

PLANS FOR 1974: A final report on the completed project should be available by the end of January.

# # #

## STUDY OF THE HARLEQUIN DUCK IN GLACIER NATIONAL PARK

INVESTIGATOR: Craig R. Kuchel  
University of Montana

OBJECTIVES: To obtain descriptive and quantitative data on the life history of the Harlequin Duck at its breeding grounds in Glacier National Park. The results of this preliminary research will be contained in a paper prepared as a senior thesis in wildlife biology at the University of Montana. The findings will also be used to determine the potential of the project for continuation at the graduate level. Findings will be made available to the National Park Service for interpretive use and to facilitate the possible formulation of a management policy toward the Harlequin Duck in Glacier National Park.

METHODS: Data were gathered through personal observation and measurement. Information on courtship activities and rearing development of young was recorded. Breeding and courtship data were obtained by observation of activities of all individuals and pairs which could be located on McDonald Creek between McDonald Falls and Logan Creek. Information on rearing activities and development of young was obtained primarily through daily location and observation of two Harlequin females with broods. This aspect of the study covered brood activity from shortly after hatching until fledging and migration.

RESULTS AND DISCUSSION: Available information shows that Harlequins arrive unpaired on the breeding grounds in late April (earliest recorded sighting is 26 April 1968). In late May I began making my observations. Pair formation and courtship were already well underway. On 2 June, 17 individuals were observed including five pairs. By mid-June few ducks were evident on the stream and of six ducks observed on 11 June, four were males and two were females which were apparently still unpaired. The majority of the females had presumably already located nest sites, and many had begun to lay eggs and incubate them. By 26 June only a lone female could be located. Corresponding to this period of egg laying and incubation in the latter part of June, the males began to disappear. By the end of June (after 26 June), no more males could be located. It is assumed that they had already begun their return migration to the Pacific Ocean where they undergo their flightless, prebasic molt in large flocks.

Data on pair formation and courtship behavior revealed that females tend to remain relatively stationary on the creek, while males travel considerable distances along the creek in search of potential mates. If any territoriality exists, it is in relation to the female rather than a physical location. The means of travel that bachelor drakes employ is upstream flight followed by long bouts of downstream floating. When potential mates are encountered, aggressive behavior patterns follow. If these fail to result in pair formation, the male merely continues his downstream trip. Since my observations began in late May, the peak of courtship behavior may not have been observed. However, this behavior had generally subsided by the middle of June.

Attempts to locate the nests of brooding females were entirely unsuccessful.

However, at least seven different broods were observed comprising a total of 31 young. The mean brood size, calculated from observations of broods at or near fledging, was 4.4 young. This figure, however, does not reflect clutch size or brood size in the early stages.

Two broods were observed almost daily from 1 July to 25 August. The majority of my findings regarding rearing and development of young are based on these observations.

Adult Harlequins feed mainly by diving in areas of fast current and stony bottoms. They do also feed, however, by tipping up and by dipping only their heads. The newly hatched broods spend the majority of their first 2 or 3 weeks in shallow flood-plain ponds adjacent to the stream. It is probably in these areas that nesting occurs also. The young, in their first 3 weeks, feed by dipping just their heads. They then begin

to feed by diving and spend increasing amounts of time in the fast current of the creek. By the age of 4 weeks, most of the time is spent in the creek.

Broods remain attached to their rearing territory for about 6 weeks. However, after the young are about 4 weeks old, the rearing territory is constantly expanded in a downstream direction. Finally, in the last 2 weeks before fledging, the broods leave their territory, moving downstream to the rapid area immediately above McDonald Falls. Here they feed by diving in extremely rapid areas where the stream bottom consists of bedrock. Between 27 July and 25 August, five different broods were observed moving into and using this area above the falls. The young were all within a few days of fledging and, in each case, they disappeared from the area within a few days.

It appears that the broods use this section of the creek as a staging area for the fall migration. Apparently, each family group remains intact, migrating as a family unit as soon as the young are fledged. No concentrations of migrating ducks were ever seen.

Data on the two broods observed most closely revealed an 83% survival rate from the age of approximately 1 week to fledging. Mortality is probably highest in the first week (Bengtson). The chief cause of mortality of young is probably mink predation, though ravens and Goshawks were also observed in the vicinity of the broods.

Observations were also made regarding the effects of human intrusions. The broods observed frequented secluded areas which were only accessible by wading the stream or following game trails through dense brush. However, as the water level in McDonald Creek dropped rapidly in the dry summer of 1973, access by fishermen and wanderers was facilitated. In two instances, human activity seemed to disrupt the normal activities of broods observed, causing attempts to abandon the rearing territory prematurely. One brood was successful in moving to a new territory downstream, approximately 1.5 miles, in the Moose Country area. The other brood was seen walking near the shoulder of Going-to-the-Sun Road in an attempt to move around a series of 20-ft falls while moving upstream. The attempt failed when eager photographers and onlookers forced the mother to return to the creek with her brood. This brood was never located again after 24 August when the attempted move was observed.

**CONCLUSIONS:** The Harlequin Duck is locally abundant along McDonald Creek since this section of the creek appears to offer optimal breeding habitat to this unique species. The Harlequin's dual requirement for breeding success, suitable habitat and relative seclusion, is met in few places in Montana. Therefore, the Glacier population deserves further study in an effort to obtain information which can be used to insure the survival of the Harlequin in Glacier in the face of increasing tourist pressure.

**Reference:**

Bengtson, Sven-Axel. 1964-65. Field studies on the Harlequin Duck in Iceland, Rep. Wildfowl Trust 17.

# # #

ATTITUDES AND PERCEPTIONS OF BACKCOUNTRY USERS  
TOWARD GRIZZLY BEARS IN GLACIER NATIONAL PARK

**INVESTIGATORS:** Ronald W. Hodgson)  
David Mihalic ) Michigan State University  
Margot Freeman )

**OBJECTIVES:** (1) To describe visitor attitudes and perceptions (images) of grizzly bears in Glacier National Park; (2) to determine visitor characteristics related to attitudes and perceptions of grizzly bears; (3) to relate images and

attitudes to resource use by visitors; (4) to analyze the information system through which visitors gain information, attitudes, and images of grizzly bears; and (5) to make recommendations to the National Park Service on ways of improving the effectiveness of the grizzly bear information system.

**METHODS:** A sample of 318 visitors to Glacier National Park during the summer of 1973 was interviewed to establish attitudes and perceptions of grizzly bears, resource use patterns, characteristics, and communication behavior. A census of the unofficial communications about bears available to visitors in the vicinity of the west entrance was made. The messages were analyzed for content pertinent to visitor images of bears.

**RESULTS AND DISCUSSION:** The analysis of data is too incomplete, at this time, to permit an adequate summary of results or a discussion of the significance of the findings. One paper has been drafted describing two dimensions of the grizzly bear image held by visitors to Glacier National Park. They are an aesthetic dimension and a safety dimension. Visitors saw the grizzly as very aesthetic but as only slightly dangerous. The paper is being edited and should be available to the Park Service by 1 April 1974.

An analysis of the unofficial communications about bears available to the public in the vicinity of the west entrance showed serious messages on how to behave toward bears constitute only 7% of the total. Messages that could be construed as portraying bears as not dangerous constituted 41.3% of the total. The remainder were neutral messages about the biology or form of the bears (such as statues, etc.) (Table 1).

A preliminary sorting of visitor concerns about where grizzlies should and should not be allowed was conducted. Table 2, below, tabulates the responses of 108 randomly selected responses to the question, "It is all right for grizzly bears to roam free..." to which the six possible endings in Table 2 were offered. Visitor response is tabulated in Table 2.

Table 1: Unofficial Messages About Bears  
in the McDonald Valley & West Glacier

Message	Frequency of occurrence
Bears are Cute People	9.3%
Bears are Cute	32.0%
Bears are Bears (Neutral)	39.5%
Bears Have These Biological Habits	12.2%
Bears Should be Treated in This Way by Man (Serious)	7.0%
Total	100.0% N equals 172

Table 2: Percentage of Respondents Agreeing and Disagreeing with Possible Endings for the Sentence, "It is All Right for Grizzly Bears to Roam Free. . ."

Agree	Disagree	Sentence Endings
19%	81%	...around campgrounds and lodges in the park.
76%	24%	...along roads and highways in the park.
94%	6%	...in all of the backcountry of the park.
99%+		...in that portion of the backcountry of the park not used by many hikers.
99%+		...in wilderness areas outside the park.
99%+		...in remote areas of northern Canada and Alaska.

CONCLUSIONS: No conclusions are offered at this point because data have not been sufficiently analyzed. Two other major papers are being prepared and several shorter summaries are planned. It appears the visiting public may have an image of the grizzly that would predict inappropriate behavior. The communication setting at the park outside the control of the Park Service may be hampering the effectiveness of bear warning communications. The situation deserves careful analysis by qualified communications scientists.

#### THE RELATIONSHIP OF AN INSECT INFESTATION ON LODGEPOLE PINE TO FLUORIDES EMITTED FROM A NEARBY ALUMINUM PLANT IN MONTANA

INVESTIGATORS: Clinton E. Carlson)  
Wayne E. Bousfield) U.S. Forest Service

OBJECTIVES: To determine if fluorides emitted from the Anaconda Aluminum Co. at Columbia Falls were related to a severe insect epidemic on lodgepole pine in the area.

METHODS: A series of 40 plots, 6 of which were in Glacier Park, was distributed throughout the infestation. Quantitative estimates of populations and damage caused by pine needle miner (*Evagora* sp.), needle-sheath miner (*Zelleria hainbachii*), pine needle scale (*Phenacaspia pinifoliae*), and sugar pine tortrix (*Choristoneura lambertiana*) were made. Estimates of ambient fluoride, needle tissue fluoride concentration, and foliar fluoride damage also were made at each plot.

RESULTS AND DISCUSSION: Stepwise multiple regression techniques were used to analyze the data. Needle miner and sheath miner populations and subsequent feeding damage were the only factors significantly correlated (95% level of confidence) with ambient fluoride and needle tissue fluoride concentration. As fluoride increased, so did the populations and damage caused by the insects. Fluoride damage also was significantly correlated with ambient and tissue concentrations of fluoride. The sugar pine tortrix and pine needle scale were at low populations and were not significant in the regression.

Visible damage to lodgepole pine in the Teakettle Mountain-West Glacier area has been ascribed solely to foliage-feeding insects according to University of Utah professors. It has been our contention, however, that it appeared more than coincidental that the perimeter of the infestation closely followed the boundary of fluoride pollution and that severity of insect damage increased in the moderately polluted areas. This study supports that premise.

We conclude that because the sheath miner and needle miner populations are significantly correlated with the degree of fluoride found in the air and in needle tissue, there is a high likelihood that fluorides have predisposed the lodgepole pine to attack by insects; however, the mechanism is not known.

This study will be published early in 1974.

# # #

## GEOLOGY OF GLACIER NATIONAL PARK

INVESTIGATORS: David D. Alt )  
Donald W. Hyndman) University of Montana

OBJECTIVES: To interpret and synthesize, for the traveling public and for the advancement and understanding of the geology of the area, the processes which led to development of Glacier National Park as it now exists and which continue to change as a part of the overall ecosystem. To reinterpret major aspects of the geology of the area in the light of modern discoveries in geology, aspects which have been incorrectly interpreted in the past.

METHODS: Literature on the geology of the park and of the whole surrounding region was thoroughly reviewed as a background for field studies of the best exposures of the rocks and of current processes affecting them and the landscape. Particular attention was paid to aspects of the geology which must necessarily link conclusions determined for one rock unit or process with those determined for an adjacent one.

RESULTS AND DISCUSSION: The present phase of our investigation culminated at the beginning of the summer (1973) in the publication of *Rocks, Ice, and Water -- The Geology of Waterton-Glacier Park*, a predominantly roadside, layman's guide to the geology and surface processes of the park. Geology off the road is the same as that seen along the road. Numerous photographs, both black-and-white and color, and line drawings illustrate features and relationships. The intent throughout was to discuss the salient aspects of the geology in words which the nontechnical traveler can easily read while conveying an accurate and modern interpretation. Scientific terminology was reduced to a minimum and jargon eliminated.

Several important aspects of the geology of Glacier Park required reinterpretation beyond that reported either in publications of the park or elsewhere in the scientific literature:

The Tertiary High Plains surface east of the park is interpreted in terms of the arid climate existing at the time and related to the present topography and geology of the park.

The large glacial valleys within the park are related to the original ancestral stream valleys and the High Plains Surface.

Glaciation in the area of Glacier Park is related to an increase in precipitation which terminated sedimentation on the High Plains Surface and initiated glaciation in the adjacent mountains.

The prominent green and red colors of the Appekunny and Grinnell formations, respectively, are related to muds kept fresh by rainfall versus those becoming alkaline while drying in the sun. Sedimentation of large parts of the Precambrian section in the park appears to have been nonmarine.

The classis Lewis Overthrust fault is attributed to gravity sliding eastward, leaving the Northfork valley and Flathead valley to the west as pullaparts.

The appearance of the "Appekunny" formation in the western part of the park is much like the Prichard formation elsewhere in western Montana, suggesting either a rapid facies change eastward from Prichard into Appekunny or that the "Appekunny" of the western part of the park is not correlative with that to the east. This point was not discussed in the guidebook but will be pursued by the authors and their students.

Separate trips were made by the investigators after publication of *Rocks, Ice and Water*, to discuss the geology of the park, including the new interpretations, with groups of Glacier Park naturalists in West Glacier and St. Mary. As in the book, considerable emphasis was given to the present processes shaping the landscape of the park and the way these processes fit in with the overall ecological balance of the area.

PLANS FOR A continuing interest is maintained in the geology of Glacier National  
FUTURE: Park. Continuing contact with Ed Rothfuss, Chief Naturalist, who initiated contact with the investigators and followed through with efforts to encourage preparation of the new visitor-oriented publication, is anticipated, as with other naturalists in the park.

One graduate student, Peter Mejstrick, is well along in a petro-chemical investigation of the Purcell Sill, at our suggestion. Others will follow.

We hope to have an opportunity to study further and prepare similar visitor-oriented publications on other national parks in the western states.

Publications:

Alt, D., and D. Hyndman, 1973. *Rocks, Ice, and Water -- The Geology of Waterton-Glacier Park*. Mountain Press Publishing Co., Missoula, Montana, 104 p.

# # #

#### MONTANA FOREST HABITAT TYPES

INVESTIGATORS: Stephen F. Arno )  
Bernard L. Kovalchik) U.S. Forest Service  
Robert Pfister )

SUMMARY OF A habitat-type classification for forests of Montana has been developed  
PROGRESS: and is now being refined using a data base of over 1400 stands. These samples of relatively undisturbed forest communities represent the spectrum of forest environments found in western and central Montana. Several plots were taken in Glacier National Park during 1971 and 1972 and samples taken earlier by Rexford Daubenmire and James R. Habeck are being utilized also. A review draft of the final classification system will be published in June 1973 and a copy will be sent to the park biologist.

# # #

## DISTRIBUTIONAL FLORA OF WETLANDS OF NORTHWESTERN MONTANA

INVESTIGATOR: Marie Mooar  
University of Montana

SUMMARY OF Nothing was added to the collection from Glacier Park. Annotations of  
PROGRESS: species are being made and identification are being rechecked.  
All locations found for each species will be on outline maps making it  
simple to find those found in Glacier National Park.

Specimens are now at University of Montana Biological Station, Bigfork, Montana,  
but will be taken to the Botany Department of the University of Montana, Missoula, on  
completion of the project. The grasses may not be included in report.

# # #

## BIOSYSTEMATICS OF *SALIX* (WILLOWS)

INVESTIGATOR: Robert D. Dorn  
University of Wyoming

SUMMARY OF Twelve specimens of *Salix* were collected for chemical analyses or for  
PROGRESS: voucher specimens for chromosome counts. Two counts were obtained  
for *S. commutata* which had not been counted previously.

# # #

## PETROLOGY OF THE PURCELL SILL, GLACIER NATIONAL PARK

INVESTIGATOR: Peter F. Mejschick  
University of Montana

SUMMARY OF Study has centered about the detailed description of 60 thin sections  
PROGRESS: representing vertical sampling at seven locations between the northwestern  
and southeastern boundaries of the park. Point counts and chemical  
analyses used to indicate trends in compositional variation are in the process of  
completion.

Interpretations are tentative until further data compilation.

Maximum thickness of the sill is 105 ft and assuming as other investigators have, the  
overlying Purcell basalt is temporarily related, these factors would imply a rapid  
glaciation history. There are, however, distinct vertical (and horizontal) variations  
in composition and the development of a xenophytic zone with a maximum extent of 20 ft.  
It is proposed that this zone is the result of assimilation of both granitic basement  
rocks and underlying dolomites, these xenoliths, being less dense than the magma, floated  
upward to collect together.

STUDIES OF THE SYSTEMATICS AND ECOLOGY OF NORTH AMERICAN TRICHOPTERA (CADDISFLIES)

INVESTIGATOR: Glenn B. Wiggins  
Royal Ontario Museum

SUMMARY OF PROGRESS: The project outlined above is a broad designation of a long-range study. Approximately 30 papers have been published from it to date. Now nearing completion is the manuscript for a 300-page reference book Larvae of the North American caddisfly genera. The primary purpose of the project is to make the larvae of the 1000-plus species of North American caddisflies better understood biologically. The book referred to will accomplish much of this goal at the generic level. A great deal of study is still to be done at the species level. The work is proceeding as planned.

Collections were made in Glacier National Park in the attempt to further document larval-adult associations for caddisfly species. This was, in fact, accomplished for two species. The attached list provides identifications of all species taken within the park during the 3 days that I worked there in 1973. All specimens have been added to the permanent research collections of the Royal Ontario Museum where they will be used in future taxonomic studies associated with this project.

# # #

PHYLOGONY OF THE WORLD *RHYACUPHILA* (TRICHOPTERA: RHYACUPHILIDAE) BASED ON LARVAL

INVESTIGATORS: Stamford D. Smith  
D. L. Peck

SUMMARY OF PROGRESS: This project requires collecting throughout western North America; Glacier National Park contains some interesting endemic species critical to the overall study of *Rhyacophila* larvae. Collections made in and around the park in 1973 were helpful; however, we were too late for many species that we expected to collect. Hopefully, more collections can be made in 1974.

In 1973 collections were made at only four sites within Glacier National Park. Most collections were made outside of the park so as to have the least possible ecological impact on systems within the park. All of our collections were made in stream habitats.

It would help us greatly if we could return to Glacier during the summer of 1974 in an attempt to pick up more key larval specimens.

Collection Sites:

Bowman Cr. at Bowman Cr. Campground, Glacier National Park, Lincoln Co. Mont. VIII-1-73  
D. L. & J. L. Peck, 144.  
Quartz Cr. Glacier National Park, Lincoln Co. Mont. VIII-1-73 D. L. & J. L. Peck, 145.  
Dutch Cr. Glacier National Park, Lincoln Co. Mont. VIII-1-73 D. L. & J. L. Peck, 147.

*Rhyacophila* larva from the acropedes, angelita, and vaccua groups were collected.

PALEOMAGNETIC STUDIES OF THE BELT SERIES

INVESTIGATOR: Icaro Vitorello  
University of Michigan

SUMMARY OF PROGRESS: Due to a 4-month delay in delivery of the shipment of rock samples from Kalispell to Ann Arbor by the motor freight company, measurements and demagnetization of the specimens will start only in the summer

# # #

# GRAND CANYON

## BASALTIC LAVAS IN THE WESTERN GRAND CANYON REGION OF NW ARIZONA AND ADJACENT UTAH

INVESTIGATOR: M. G. Best  
Brigham Young University

SUMMARY OF LATE Cenozoic volcanism concurrent with block faulting in the transition  
PROGRESS: zone between the western Colorado plateaus and the eastern basin and  
range province has created a suite of essentially alkalic basaltic rocks  
similar to those occurring in other regions of recent uplift, extensional tectonism, and  
high heat flow. Hawaiiite is the most widespread type of lava and was produced throughout  
the 7 million year period of volcanism. Low pressure differentiates include sodic  
hawaiiite transitional to mugearite and peralkaline rhyolite. Basanite and alkali  
olivine basalt lavas, many containing peridotitic inclusions, rank second in volume and  
were mostly extruded within the last million years. Minor differentiates include  
ankaramite and analcime hawaiiite. Flows of quartz-bearing basaltic andesite 2-3 million  
years old are locally prominent.

The major types of lava display an essentially continuous compositional spectrum not  
governable by crystal fractionation and transecting low pressure thermal divides. These  
properties, together with low initial  $\text{Sr}^{87}/\text{Sr}^{86}$  ratios = 0.7039 (20 samples) relative  
to 0.7080 for Eimer and Amend standard and compositional affinities to proxene-olivine-  
liquid invariant points in peridotite systems at high pressures, suggest derivation of  
the lavas as a series of partial melts of the mantle, modified to varying degrees by  
polybaric fractionation of olivine and possibly plagioclase and clinopyroxene during  
ascent to the surface. Utilizing O'Hara's projections in the CMAS tetrahedron as  
guides, it is concluded that the basanites originated as magmas at depths of at least  
65 km and possibly as much as 95 km (20 to 30 kb) by variable but generally small degrees  
of partial melting. Hawaiiite magmas originated at shallower depths than basanite by  
a somewhat greater degree of partial melting and were more substantially modified by  
crystal fractionation prior to extrusion. Xenocrystic-appearing quartz and plagioclase  
in the basaltic andesite are interpreted as high pressure liquidus phases which suffered  
partial resorption just prior to eruption, rather than being accidentally derived.  
These lavas were derived from partial melts formed slightly shallower than hawaiiite  
magmas but otherwise experienced a similar pattern of evolution.

Similar specific magmatic associations occur in other marginal areas of the Basin and  
Range province, in the eastern Australia-Tasman Sea-New Zealand region, and in the region  
trisected by the Red Sea, Gulf of Aden, and Ethiopian rifts. Development of the  
association appears to accompany continental rifting and both are a response to regional  
upwelling of the upper mantle.

In the western Grand Canyon, the magmas parental to the extruded lavas became  
increasingly divergent chemically with time, reflecting a broadening depth interval of  
partial melting in the mantle. Concurrent eruptive activity and block faulting  
generally shifted eastward with time at a rate of approximately 1 cm/yr. These time-  
space-composition variations, in combination with the observed essentially marginal  
localization of basaltic volcanism for the whole Basin and Range province, are explained  
in terms of upper mantle dynamics. We envisage upwelling mantle or plume activity  
beginning sometime in the middle to late Cenozoic in the core area of the Basin and Range  
province and causing progressive thinning or "erosion" of the lithosphere. Erosion  
ultimately produced a lower lithosphere boundary much like that at present. Lateral flow  
of the upper mantle from the core of the plume was throttled in the region of the deep  
lithospheric keel beneath the Colorado Plateaus. Localized heating in the throttled  
region by the thermal feedback mechanism of Shaw was sufficient to raise the ambient  
peridotite temperature so that partial melting and ultimate volcanism was made possible.  
Viscous heating, partial melting, and kneading of the melt from the crystalline residuum

may have induced local diapiric activity which further weakened and attenuated the overlying brittle crust, causing concurrent faulting. Eastward erosion of the keel allowed eruptive and fault activity to migrate.

# # #

### BIGHORN SHEEP INVESTIGATION

INVESTIGATOR: Neal G. Guse, Jr.  
National Park Service (WASO)

SUMMARY OF PROGRESS: This report discusses the first season results (1972) of a postcard survey project for reporting desert bighorn sheep along the Colorado River in Grand Canyon National Park, Arizona. Prior to the river-running season, approximately 600 postcard forms were distributed to approved concessioners, private parties, and NPS patrols. Over 100 sightings were recorded and later analyzed to determine the opportunities for observing sheep, delineating sites of repeated observation, and collection of limited life history data. The postcard survey appears to be the most promising method for gathering information about sheep in this region. This is due to the joint use of the Colorado River: the sheep are dependent on the river as the primary source of water during the hot summer months; and the river also provides an important outdoor, water-based recreation opportunity. The major limitation of this method is the lack of trained observers to record accurately and completely at the time of observation specific details about the sheep and their habitat. However, for the purposes of this survey, this deficiency was not too significant since the primary objective was to simply locate the sheep and select optimum sites for future study.

# # #

### STRATIGRAPHY OF THE DOX FORMATION (PRECAMBRIAN), GRAND CANYON NATIONAL PARK, ARIZONA

INVESTIGATOR: Gene M. Stevenson  
Northern Arizona University

SUMMARY OF PROGRESS: Thesis completed 28 August 1973. Copies available from Northern Arizona University Library or Geology Dept. Dox formation is proposed to be divided into four members, also a Hernate type section for the Dox is proposed to be moved to large exposure in Unkar Valley. Algal stromatolites found (primitive algal forms). More detailed work on the members (i.e., petrography, clay mineralogy). The structural geology in the Tanner Canyon area is extremely complex and detailed mapping should be worked out.

INVESTIGATION OF THE SUPAI AND HERMIT FORMATION OF GRAND CANYON

INVESTIGATOR: Edwin D. McKee  
U.S. Geological Survey

SUMMARY OF PROGRESS: The tabulation of data, preparation of illustrations, and writing of manuscript are all moving ahead at this time and several sections of the paper are already well advanced, viz., the unconformities and key beds used for subdivision, the description of cross-bedding, the zonation of fossils and age implications. Current emphasis is on the petrology, sand texture, and clay constituents.

Significant findings are (1) the Supai Formation is divisible into four district rock units on the basis of lithology, faunal differences, and erosional surfaces marking boundaries; (2) marine fossils occur in most units throughout the Grand Canyon, implying a near shore marine environment; (3) the source of sediment was to the north, probably in Utah, and sand was transported in a southerly direction.

# # #

GEOLOGIC STUDY OF YOUNGER PRECAMBRIAN BASALTIC ROCKS  
OF THE GRAND CANYON, ARIZONA

INVESTIGATORS: John D. Hendricks)  
Ivo Lucchitta ) U.S. Geological Survey

SUMMARY OF PROGRESS: Field and laboratory work completed, reports written and are now in the process of publication.

Provides a general description of these rocks not in existence prior to this study, especially the relationship between the intrusive and extrusive rocks. More detailed work would be useful but no schedule of work has been made. We are primarily waiting for reaction to the initial study.

# # #

CONODONT BIOSTRATIGRAPHY OF THE MISSISSIPPIAN ROCKS (REDWALL L.S.)  
OF NORTHWESTERN ARIZONA

INVESTIGATOR: David R. Walter  
Arizona State University

SUMMARY OF PROGRESS: Work on the project has been temporarily stopped due to work on the carbonate geology of the Eniwetok Atoll, Marshall Islands. This requires much travel to and from the islands. It is hoped that work will again be in full swing on the project in August or September 1974. Goals and findings of the study on Conodonts remain the same as stated in earlier reports.

FERAL BURRO MANAGEMENT  
GRCA-N-17

INVESTIGATOR: Neal G. Guse, Jr.  
National Park Service (WASO)

SUMMARY OF PROJECT: Project has largely been held in abeyance following the transfer of the assigned investigator--Neal G. Guse, Jr., in September 1972. Since the crucial question of the burro's influence and effect on desert bighorn sheep has not been answered, this project merits high priority in terms of current park research needs.

# # #

GEOLOGY OF THE CARDENAS LAVAS

INVESTIGATORS: Ivo Lucchitta )  
John D. Hendricks) U.S. Geological Survey

SUMMARY OF PROJECT: Field and laboratory work complete, reports written and are now in the process of publication. Provides a general description of these rocks and the environment of deposition. Future work necessary but not planned.

# # #

INVESTIGATIONS ON AQUATIC HEMIPTERA

INVESTIGATOR: John T. Polhemus  
University of Colorado Museum

SUMMARY OF PROJECT: A biological survey of aquatic hemiptera was carried out in the canyon. One undescribed species of *Ochterus* (Ochteridae) was found, which was previously known to me. The material has been identified, and a paper is in preparation.

# # #

REVISION OF THE MOSS GENUS *PHILONOTIS* IN NORTH AMERICA

INVESTIGATOR: William M. Zales  
Joliet Jr. College

SUMMARY OF PROJECT: The genus *Philonotis* (Musci) is revised for North America, north of Mexico, and exclusive of Greenland, following the last revision for this region by Seville Flowers in 1935. Collections and field observations of all

but two of the recognized taxa were made from a wide diversity of habitats throughout most of their geographic range in North America. Numerous collections were cultured in a uniform environment to determine the stability of taxonomically diagnostic morphological characters. The position of papillae on the leaf cells, the structure of marginal cells, and to some degree the leaf shape and leaf cell shape are stable characters that are not modified by the environment. All other morphological characters examined are ecophenic and cannot be utilized to segregate taxa.

The present revision recognizes seven species and two varieties; *Philonotis glaucescens* (Hornsch.) Broth., *P. longiseta* (Rich. in Michx.) Britt., *P. sphaerocarpa* (Hedw.) Brid., *P. marchica* (Hedw.) Brid., *P. capillaris* Lindb. ex Hartm., *P. fontana* (Hedw.) Brid. var. *fontana*, *P. fontana* var. *americana* (Dism.) Flow. ex Crum, *P. fontana* var. *pumila* (Turn.) Brid., and *P. yezoana* Besch. et Card. in Card. (new to North America).

Chromosome counts of  $n = 6$  for *P. glaucescens* and  $n = 12$  for *P. longiseta* are new reports.

Keys, descriptions, illustrations, and distribution maps are provided for the identification of the species.

Graduate studies:

Field of study: Botany - Bryology

Bryology	H. A. Crum
Lichenology	H. A. Crum
Boreal Flora	E. Voss
Bryophyte Cytology	A. Vaarama
Phytogeography	W. B. Schofield
Paleobotany	G. E. Rouse
Electron Microscopy	A. B. Acton

Publications:

Zales, W. M., and H. Crum. 1970. *Sphagnum* in Sherlevoix County, Michigan. *The Mich. Bot.* 9(2):114-115.

Zales, W. M. 1971. Bryophytes of Goose Lake Prairie, Illinois. *Trans. Ill. Acad. Sci.* 64(3):222-224.

# # #

## AIR POLLUTION DETECTION BY LASER BEAM

INVESTIGATORS: Richard G. Layton) Northern Arizona University  
K. D. O'Dell )

SUMMARY OF PROGRESS: Useful data have been obtained since the fall of 1971. The data indicate that the air in the Grand Canyon is exceptionally clear. A typical measurement shows a transmission (5.1 mk) of 84% which gives a meteorological range for this wavelength of about 100 km. Results of as high as 150 km or as low as 75 km are not uncommon.

About 7/8 of the energy lost from the beam is due to scattering from dust and water, with about 1/8 on the average being due to the atmosphere itself. One measured range was 200 km which corresponds to 3/4 of the scattering due to dust and 1/4 due to the atmospheric gases themselves.

All results indicate that the chief scatterers are natural dust particles with sizes comparable to the wavelength of visible light. This is consistent with the natural origin being due to wind-blown dust. Results of other investigators tend to confirm this.

Now that a reasonable baseline of data exists, it is important to observe any changes due to increased use, new sources, or new external sources such as the Navajo Power plant. Although we have not achieved continuous monitoring, we expect to make modifications which will allow us to do this. In addition, we expect to integrate our results with other measurements carried out by Dr. Bill Malm of NAU. These would include weather data, high volume sampling, etc. We are also in the process of interpreting our own additional data on small ion counts and Aitkin nuclei counts obtained at the bottom for the past few years.

We would like to see this project continued on a broader plane to yield data which would give more definitive information on the size and other characteristics of the aerosol.

# # #

#### FORMATION OF RAPIDS AND EROSION OF BEACHES, GRAND CANYON

INVESTIGATOR: Arthur S. Gallenson

SUMMARY OF FINDINGS PRESENTED TO THE SUPERINTENDENT, DIRECTOR OF PARK SERVICE, AND SECRETARY OF INTERIOR 1972-73.

# # #

#### INNER CANYON DEER MOVEMENTS GRCA-N-19

INVESTIGATOR: Neal G. Guse, Jr.  
National Park Service (WASO)

SUMMARY OF PROJECT HELD IN ABEYANCE UPON THE TRANSFER OF ASSIGNED INVESTIGATOR-- NEAL G. GUSE, JR., IN SEPTEMBER 1972. ADDITIONAL ACTION SHOULD AWAIT ASSIGNMENT OF NEW INVESTIGATOR. PROJECT IS OF VERY LOW PRIORITY IN TERMS OF CURRENT PARK RESEARCH NEEDS.

# # #

#### NORTHERN ARIZONA RESEARCH PROJECT (INVESTIGATIONS OF CARBONATE AQUIFIERS AT GRAND CANYON) GRCA-N-4

INVESTIGATOR: George L. Beck  
Arizona

SUMMARY OF WATER SAMPLES COLLECTED AT ROARING SPRINGS IN THE YEAR 1972 ARE STILL PROGRESS: LOST. SAMPLES WERE DELIVERED TO NPS PERSONNEL FOR TRANSFER; THEY DISAPPEARED.

Two additional river trips were made along the Colorado River.

Major part of field work in the year was devoted to related programs on National Forest Service or Bureau of Land Management areas adjacent to GCNP.

# # #

ECOLOGY OF THE KAIBAB SQUIRREL  
GRCA-N-1

INVESTIGATOR: Joseph G. Hall  
San Francisco State University

SUMMARY OF PROGRESS: This study was not pursued during the past year so no additional findings beyond those reported in the previous Annual Report are available. During this coming field season I propose to carry out a transplant of about six marked squirrels to Shiva Temple where their movements, behavior, and feeding habits will be studied. By a quantitative recording of the latter, a reliable census technique will be worked out and is the prime goal of the plan. (A detailed proposal has been submitted to the NPS and approved by it.) Some additional funding will be needed for the helicopter travel envisioned for this proposal but the exact amount has not yet been estimated.

# # #

SOCIAL CARRYING CAPACITY IN COLORADO RIVER FLOAT TRIPS

INVESTIGATORS: Stanley K. Brickler)  
Robert Johnson ) University of Arizona  
Douglas Larson )

SUMMARY OF PROGRESS: The Social Carrying Capacity Study has been on-going for 3 years. During the peak river use seasons of 1971, 1972, and 1973, a systematic on-site investigation designed to obtain data reflecting user attitudes regarding float trip experiences was conducted by the study team. Analysis of the data and evaluation of the measurement techniques of 1971 facilitated the development and modification of new techniques which were used during the 1972 data collection period. Modifications of data collection techniques for 1972 included: (1) the development of a self-administered, open-ended, post-trip questionnaire which was distributed to float trip participants; (2) and a pre- and post-trip user-attitude paired-picture comparison interview series administered by members of the research team. During the summer of 1972, the research team distributed over 2000 self-administered questionnaires to river trip participants. Analyses of the data and measuring techniques from the 1972 research period led to the modification of procedures for 1973 field research. During the summer of 1973 the research team conducted a total of 1000 pre- and post-trip paired-picture comparison interviews and distributed a total of 3500 self-administered questionnaires to boatmen.

SIGNIFICANT FINDINGS: Univariate analyses have been accomplished on paired-picture data, and coding of the self-administered questionnaires is nearly completed. Results are still preliminary and will not be released at this time.

RECOMMENDATIONS: Recommend that the research team be funded for the analysis of data collected during the 1973 season.

# # #

DISTRIBUTION, ABUNDANCE AND ECOLOGY OF THE FISHES  
OF THE UPPER COLORADO RIVER BASIN

INVESTIGATOR: Paul B. Holden  
Utah State University

SUMMARY OF PROGRESS: Dissertation has been sent to you earlier.

# # #

CHROMOSOME VARIATION IN NORTH AMERICAN FENCE LIZARDS  
(GENUS *SCELOPORUS*; *UNDULATUS* SPECIES GROUP)

INVESTIGATOR: Charles J. Cole  
American Museum of Natural History

SUMMARY OF PROGRESS: My research on chromosomes, variation, and geographical and ecological distribution of the fence lizard (*Sceloporus undulatus*) is continuing (see report of 18 December 1972). New discoveries resulting from intensive work in central and southern Arizona this season, however, prevented my return to Grand Canyon National Park in 1973; further sampling of the populations in the park will be desirable in the future.

Emphasis in my research in 1973 was placed on analyzing samples from a hybrid zone and from additional populations that had never been sampled previously. Of particular interest was the discovery of populations with similar habitat preferences and similar external phenotypes, but having distinctly different chromosomes, being distributed in such a fashion that little or no ecological barriers currently separate them. This suggests that the lizards are now bridging a gap that existed previously--presumably indicating historical changes in distribution patterns of vegetation associated with environmental changes. This particular aspect of the problem will receive concentrated investigation in the near future.

# # #

PALEOMAGNETISM IN FOLIATED METAMORPHIC ROCKS

INVESTIGATORS: S. E. Sebull  
D. H. Shurbet

SUMMARY OF PROGRESS: Four samples of foliated metamorphic rock collected near Phantom Ranch have very low magnetic intensities, unfortunately, below that required by our present equipment. Perhaps we will achieve the required

sophistication in the future, but at present we're unable to obtain consistent results. Hence, work on these four samples is deferred indefinitely. Should we obtain viable results in the future, you will be informed immediately.

This project, utilizing rock samples from other localities, has proven successful. We find that the foliated rocks from which we have obtained good data show magnetic polarity approximately perpendicular to foliation planes. Results are nearly in manuscript form.

# # #

#### BLUE SPRINGS AS A BARRIER TO *RHINICHTHYS OSCULUS*

INVESTIGATOR: Stewart W. Aitchison  
Museum of Northern Arizona

SUMMARY OF PROGRESS: Chemical and physical parameters have been measured in parts of the Little Colorado River and associated springs. Physiological tolerance tests have been completed on speckled dace (*R. osculus*). Further work needs to be done on fish population movements in the river system.

# # #

#### GEOLOGY OF THE VISHNU GROUP OF THE GRAND CANYON

INVESTIGATOR: Malcolm D. Clark  
Museum of Northern Arizona

SUMMARY OF PROGRESS: Field work and mapping completed for both the Upper and Lower Granite Gorges. Findings summarized in papers in:  
(1) Geology of the G.C., ed. W. J. Breed, M.N.A./G.C.N.H.A., 1974.  
(2) U.S.G.S. Guidebook to N. Az., 1974. (3) Geological map of Grand C. Nat. Park, M.N.A./G.C.N.H.A., 1974.

Possibility that some calc-silicate rocks (metamorphosed limestones) within the Vishnu Group were formed by algal growth similar to that of the Bass Limestone. This would be the first record of life older than 1 billion years in the southwest United States and an unusual find in such highly deformed rocks. More work needed to confirm.

Work now oriented to detailed laboratory study, e.g. Rb/Sr dating now in progress at the University of Arizona.

# # #

#### COLLECTING OF SMALL MAMMALS IN HAVASU CANYON

INVESTIGATOR: Donald F. Hoffmeister  
Museum of Natural History, University of Illinois

SUMMARY OF  
PROGRESS:

A small collection of mammals was made within Havasu Canyon. These specimens provide us with additional information of the distribution of several species of mammals.

# # #

GRAND CANYON MARINERS

INVESTIGATOR: O. Dock Marston

SUMMARY OF  
PROGRESS:

Preliminary drafts are completed on nearly all the work and final drafts are in process. Major Powell is delayed while more of his drafts are being investigated.

A special study is being made re the claims of James White which will probably develop into publication of books. It will include a biography of White written by his granddaughter; a biography of Baker written by Virginia McConnell; a proof that White could not have gone around the Canyon written by Robert C. Euler; a proof that he could not have gone thru the Canyon written by the undersigned.

# # #

STRATIGRAPHY AND PALEONTOLOGY OF THE CHUAR GROUP

INVESTIGATORS: William J. Breed) Museum of Northern Arizona  
Trevor Ford ) University of Leicester, England

SUMMARY OF  
PROGRESS:

Four days were spent in Nankoweap collecting black chert to look for algae filaments.

The following publications resulted from the research on the Chuar.  
Reprints of material published this year enclosed.

Work has resulted in a new project on the "Origin of the Precambrian 60 Mile Formation." Would suggest this work be a different project next year. Publication on 60 Mile Formation enclosed. This project will take 3 years.

Bibliography:

- 1969 The Discovery of Orthocone Nautiloids in the Redwall Limestone - Marble Canyon, Arizona: *In* Guidebook to the Geology and Natural History of the Grand Canyon Region, Fifth Field Conference, Four Corners Geological Society, p. 134.
- 1972 (with T. D. Ford and J. S. Mitchell) Name and Age of the Upper Precambrian Basalts in the Eastern Grand Canyon. *Geol. Soc. Am. Bull.* 83:223-226, 1 fig., January 1972.
- 1972 (with Trevor D. Ford) The Chuar Group of the Proterozoic, Grand Canyon, Arizona. *Proc. 24th Int. Geol. Congr., Montreal, Section 1, p. 3-10.*
- 1972 (with Trevor D. Ford) The problematical Precambrian fossil *Chuarina*. *Proc. 24th Int. Geol. Congr., Montreal, Section 1, Publication 334, p. 11-18.*
- 1973 (with J. William Schopf, Trevor D. Ford) Microorganisms from the Late Precambrian of the Grand Canyon, Arizona. *Science* 179:1319-1321.
- 1973 (with T. D. Ford) Late Precambrian Chuar Group, Grand Canyon, Arizona. *Geol. Soc. Am. Bull.* 84:1243-1260.
- 1973 (with Trevor D. Ford) The problematical Precambrian fossil *Chuarina*. *In: Palaeontology, vol. 16, part 3, p. 535-550.*

COLORADO RIVER STUDY  
GRCA-N-15,16

INVESTIGATOR: Peter S. Bennett

SUMMARY OF PROGRESS: During the past year, my time was spent on a broad research design for this project. We have contracted with the Museum of Northern Arizona for a river research bibliography and for an inventory of the riparian habitat. The first portion of their contract has been fulfilled. It is my understanding that this bibliography will eventually be published by the museum.

# # #

THE ECOLOGICAL ROLE OF FIRE IN NORTH RIM FORESTS  
GRCA-N-18

INVESTIGATOR: Peter S. Bennett

SUMMARY OF PROGRESS: The successful removal of fire as an ecological force from the Ponderosa Pine Association on the North Rim of Grand Canyon National Park as a management policy has led to the accumulation of fuel that amounts to as much as  $2.993 \times 10^9$  kg-cal/ha. This policy has also led to significant changes in population structure, succession, nutrient cycling, and fire susceptibility.

Investigation has proceeded by careful analysis of selected plots before and after burning under documented conditions. Each site was inventoried for the species and the spatial relationships of the macrobiota (excluding insects), gross bacterial and fungal population dynamics in the soil were determined, the amount and heat content of fuels were measured, and the physical and chemical properties of the soil were determined.

A regression equation predicated on air temperature, relative humidity, and fuel moisture has been derived to predict burning intensity. The dependent variable is hereafter called the Y value. Y values have a practical range of 1 to 10.

Two research plots have been burned to date. The first was treated at a Y value of 7.98, the second, at 4.95. Both were burned in early fall of 1971 and have been under analysis since.

Data for fuel loading prior to burning, fuel consumed, and fuel added following burning are available only for the first site ( $Y = 7.98$ ). Fuel consumed was far greater than that added by leaf-fall and fire-killed trees. The fuel loading was  $2.95 \times 10^5$  gh/ha of which  $2.34 \times 10^5$ /ha was burned. Fuels added to the plot since burning are  $6.92 \times 10^4$  kg/ha, making a net consumption of  $1.64 \times 10^5$  kg/ha. Visually, this relationship is similar for the second site. The lesser fuel consumed in response to the lower Y value is partially compensated for by the lower weight of fuels added because of greater needle and tree survival.

Regression equations have been derived to give predictive values for Y values vs.  $L_{50}$  for ponderosa pine. At  $Y = 8$ , the  $L_{50}$  is 20.3 cm dbh, and at  $Y = 5$ , it is 16.5 cm dbh. The diameter and presumably the age distribution of the trees are apparent. The modal class mark lies at 10.72 cm dbh, seedlings and very small trees are all but absent.

Surviving trees show a positive response in ring width following burning. Comparison of ring widths of trees growing on the experimental sites was compared with the master tree ring chronologies for the North Rim. Abnormally wide ring series were found on

an average of every 19 years, probably indicating the frequency of fire in this portion of the forest.

These plots show significant changes in species area curves and species diversity indexes following burning. Fifty percent of the plant species present on the plots were found on 128 m<sup>2</sup> prior to burning. After burning, this figure dropped to 80 m<sup>2</sup>. The species diversity index rose from 0.079 to 0.244. Both changes are significant at the 99% level. Data were derived 2 years after burning. The magnitude of such change is apparently positively related to Y value. Small mammals and birds were found to follow a similar pattern, but the magnitude of change was much less dependent upon Y value than were plants. Burning creates new niches and space for exploitation by the biota.

Soil conductivity, pH, and the bacterial soil flora changes are positively correlated to the weight of fuel consumed. Fuel consumption is positively correlated to Y value. The gross changes in fungal biomass are not statistically significant comparing biomass.

No significant changes in water percolation rates, soil bulk density, erodability, nor organic carbon were detected below the A<sub>0</sub> soil horizon on either site.

Although data for sophisticated quantification of the metabolic pyramids and lacking, that which is available indicated that they are less steep following fire than before. There has been considerable expansion of the primary producer and herbivore trophic levels on a biomass basis.

Records maintained by the National Park Service for the North Rim were analyzed for frequency, size, and geographic distribution of fires. During the past 49 years, there has been an increase in the number of fires, but not of size. A reasonable hypothesis is that more efficient methods of fire control have kept fires small, but that the increase in number is partially a reflection of increasing fuel loads.

Tentative recommendations are made to management for the use of fire in the Ponderosa Pine Association for biological management of this resource.

## GRAND TETON NATIONAL PARK

### THE EFFECT OF FIRE ON FUNGAL AND MICROARTHROPOD POPULATIONS OF BLACKTAIL BUTTES

INVESTIGATORS: Nancy Stanton )  
Martha Christensen) University of Wyoming  
Vincent Tepedino )

SUMMARY OF PROGRESS: Forty-five litter and 45 soil samples were collected in July in each of three areas: the burn, the control, and adjacent sage/grass. All arthropods were extracted and percent moisture was determined. We are now in the process of counting all organisms present and sorting the acarina into species. Thirty-nine samples have been completed to date.

SIGNIFICANT FINDINGS: Since the area was not burned as planned, there are no significant findings.

RECOMMENDATIONS: We will continue as planned until one-third of the samples are analyzed  
At that time the decision will be made whether to expand the project  
and ask for increased support.

# # #

### A PILOT STUDY OF MODELING THE SNAKE RIVER FLOAT TRIP, GRAND TETON NATIONAL PARK

INVESTIGATOR: Alan Jubenville  
University of Wyoming

SUMMARY OF PROGRESS: Have completed field work and first draft of final report.

SIGNIFICANT FINDINGS: (1) The perception of guided floater is almost completely molded by advertising. (2) The urban visitor chooses the guided trip because he seeks to enjoy more of the parkscape while minimizing uncertainties. (3) The basic unit in determining carrying capacity should be the number of watercraft--not merely number of people. (4) The greatest potential management problem is the private visitor because visitors represent unlimited growth; whereas guided float trips are restricted in potential growth by inherent limits of the float visitor.

RECOMMENDATIONS: (1) Complete the study of perception and motivation. (2) Calibrate registration stations to adequately define the private floater population. (3) Standardize interpretive program.

# # #

### MICROBIAL STUDIES OF A HIGH ALPINE WATER SUPPLY USED FOR RECREATION

INVESTIGATOR: Gordon A. McFeters  
Montana State University

SUMMARY OF PROGRESS: Water samples were collected from specific sites within Grand Teton National Park at regular intervals and their bacterial microflora determined. These samples were collected along Leigh Creek and Glacier Gulch (areas seldom visited by man), along Garnet Creek and Cascade Creek (heavily used by man), and the lakes in the valley into which they flow. The bacterial microflora of public health significance (coliforms and fecal streptococci) were determined by standard methods. Colonies of both types of bacteria were transferred to storage media and further characterized at a later time. This characterization allowed differentiation of the nonfecal coliform bacteria (originating from sources other than the intestines of warm-blooded animals) from the fecal coliform bacteria (originating from the feces of warm-blooded animals). Therefore, these data indicate what percent of the total coliform bacteria that were isolated from the water were from the fecal contamination of some warm-blooded animal. Also, the fecal streptococci found were identified by species. This information provided a method to help identify the animal responsible for the contamination since all fecal streptococci are of fecal origin and the species of these bacteria are characteristic of the animal feces in which they are found. For example, it was determined that human fecal material has a significant population of *Streptococcus faecalis* which is not found in animal droppings. In addition, this method can sometimes be used to differentiate water contamination by domestic animals versus wild animals.

The results of this year's study, like last year's in Leigh and Cascade canyons showed no evidence of gross contamination. The bacteria that were found in the waters of these two drainages reflected an impact of man's presence in that there was slightly better overall quantitative quality water, from a microbiological standpoint, in the drainages that were heavily used by man (Cascade and Garnet canyons). In each of the study areas, less than 20% of the coliform bacteria that were isolated were of fecal origin.

Moreover, the species of the fecal streptococci from Leigh and Garnet canyons and the valley lakes indicated that wild animals were responsible for the contamination while some evidence of human contamination was found in Cascade Creek. This finding is significant in that no evidence of human contamination was found in any of the study areas last year. On this basis, it is recommended that this aspect of the study be continued for at least one more year, with the identification and differentiation of greater numbers of bacteria from the water at a few key sites in all of the present study areas. This would be a concentration on critical areas that would provide greater definition of the impact of human activities on the quality of the waters within Grand Teton National Park.

Another aspect of the overall water quality picture within Grand Teton National Park that was observed in 1972 was again seen this past year. The indicator bacterial population was very low (average data are: total coliform  $\leq 10/100$  ml and fecal streptococci  $\leq 5/100$  ml) in the upper regions of the park where the water originated from snow-melt or as springs. As this water flowed toward the valley, the bacterial density increased (average data are: total coliform  $\leq 25/100$  ml and fecal streptococci  $\leq 10/100$  ml) as a result of the biological community in the canyons. Our data further indicated that man had little impact on the water quality within the framework of the visitor-use management that is practiced within Grand Teton National Park. Finally, once the water was within the valley lakes where the flow was reduced and there was minimal addition of bacteria by animals, the bacterial population diminished because of die-off. For example, water samples taken from the boat dock at Jenny Lake consistently had the lowest bacterial counts of any water that was analyzed within Grand Teton National Park (average data: total coliforms  $= 5/100$  ml).

The samples that were analyzed from Garnet Canyon reflected a similar pattern to that observed in Cascade Canyon. Little evidence of gross contamination was found in spite of the intense use and virtual absence of sanitary facilities or topsoil that could be used to bury human waste. On the other hand, consistently high counts (average data: total coliform  $= 200/100$  ml) of indicator bacteria were isolated from the creek that drains Glacier Gulch. This result was unexpected and is still under investigation. However, at present it appears that glacial silt might promote the growth of an algal community that was observed on the rocks in that stream and in turn, provides a suitable environment for the growth of some types of nonfecal indicator bacteria. This finding is of considerable interest since it represents an aquatic ecological situation that is novel to glaciated alpine regions. Since many such regions are administered by the National Park Service, a more complete understanding of this phenomenon would be of practical importance to the National Park Service in addition to its scientific merit. For example, at this point one cannot be sure that these bacteria are not a health hazard; in fact, some evidence from Glacier National Park suggests that they may be. It is recommended, therefore, that this aspect of the study be intensively investigated for at least one more year.

Water samples taken below the outflow of Jenny Lake demonstrated a dramatic change that reflected an adverse human impact. As the water left Jenny Lake, it was of very high microbiological quality and about 600 yards downstream (directly below the horse coral) the count of indicator bacteria increased by a factor of 10 to 20. Since these water samples taken along Cottonwood Creek were analyzed only this past summer and inconclusive differential results were found, it is recommended that this aspect of the project be continued and studied in more detail for at least one more year. The information gained from this part of the study would help determine the source of the contamination. In this connection, an observation related by the Rangers who lived in the cabins below the Lupine Meadow bridge and drank this water is thought to be significant. They indicated that most of the people who lived in this area experienced severe intestinal upset at least once every summer. It is likely that this observation

is directly related to the contamination that was detected in our study. It is further recommended that immediate steps be taken to provide the cabins with a safer supply of water. Alternatives might include an interconnect with the water system that serves the Jenny Lake Campground or a separate supply from Jenny Lake.

In summary, our findings have identified three situations that we feel deserve further study on the basis of their scientific merit and the usefulness of the resulting information to the National Park Service. These three aspects are: (1) a more concentrated and detailed investigation of key sites to determine the impact of visitor use on the safety of park waters; (2) an intensive study of the aquatic ecosystem in Glacier Gulch to establish the role of glacial activity on microbial water quality; and (3) a more detailed chemical and microbiological examination of the water from the boat dock at Jenny Lake to one mile downstream on Cottonwood Creek to define the source of contamination observed in that watercourse. These are the focal points of aquatic microbiological interest that have developed as a result of the investigation that was done over the past two summers. The recommended continuation of this study would afford a much greater definition of the impact of human activities on the water quality and safety within Grand Teton National Park. It is further proposed that the time schedule and the support level be expanded somewhat for the upcoming research period. The redesign of the study would be accomplished by one student, Bo Stuart, under the direction of the principal investigator. It is proposed that this student, who has worked on the project over the past 2 years, work in Grand Teton National Park from 1 July thru the end of September 1974, and then continue the laboratory phase of the investigation (differentiating and identifying the bacteria collected in the summer) through the 1974-75 school year on a part-time basis. The proposed detailed budget is listed below.

The assistance of Bo Stuart, Jim Hawkins, Dr. Dave Stuart, Dr. Jim Jezeski, and the support of the National Park Service and the New York Zoological Society are gratefully acknowledged.

# # #

#### VEGETATION MAP OF JOHN D. ROCKEFELLER, JR., MEMORIAL PARKWAY

INVESTIGATOR: Alan A. Beetle  
University of Wyoming

SUMMARY OF DURING the field season 1973, detailed notes were taken on the distribution  
PROGRESS: and composition of the major vegetation types in the John D. Rockefeller,  
Jr., Memorial Parkway. The field work is done and the map is in  
preparation.

Preliminary results indicate that the parkway is ecologically in between an area of great stability in southern Yellowstone and an area of great ecological instability in Grand Teton National Park. Another year of study in this area could provide a blueprint for future changes and of probable rates of change for Grand Teton National Park.

# # #

#### VARIATION AND ECOLOGY OF ASPEN

INVESTIGATOR: Alan A. Beetle  
University of Wyoming

SUMMARY OF            During 1973 a manuscript entitled Range Survey in Teton County, Wyoming,  
PROGRESS:            Part IV--Quaking aspen was finalized and passed through two reading  
                         committees. The manuscript is now awaiting publication.

In May 1973 the sex of aspen was determined throughout the Jackson Hole area. It was found that male clones were more common throughout, but that both male and female clones occupied all sites at all elevations.

In June some of the female clones were found to bear mature catkins, and the seed from these catkins was determined to be viable at the Wyoming State Seed Laboratory. These seeds were shed over a month-long period but careful observation failed to reveal any field germination. In September the same clones were visited and were found to be responding to fall temperatures in different ways but always as clones, some of them dropping leaves earlier or turning a different shade of color.

Observations were made on attempts at experimental burns.

# # #

THE STUDY AND EVALUATION OF NATURAL AREAS OF THE WYOMING BASIN  
THAT MAY QUALIFY FOR THE REGISTRY OF NATIONAL LANDMARKS AND BE  
USEFUL IN FUTURE PLANNING OF THE NATIONAL PARK SYSTEM

INVESTIGATOR:    Paul O. McGrew  
                         University of Wyoming

SUMMARY OF            A preliminary list of nine areas suggested by Drs. Harrison, Knight,  
PROGRESS:            McGrew, and Mears (in October 1972) for evaluation as potential Natural  
                         Landmark sites has been expanded to 48 potential sites and, after  
literature study and reassessment, has been reduced to 35 geologically important sites. Of these sites, 30 have now been evaluated through literature search and/or field reconnaissance and evaluations are available in the form of preliminary (first draft) reports. The remainder of 1973 and the first few months of 1974 will be used to complete the study of the remaining five potential sites and to edit material to be included in the final report. Brief introductions to the geologic natural history themes have been prepared for those themes which are well illustrated by natural areas within the Wyoming Basin.

The sites presently evaluated are: Dallas Dome, Wind River Badlands, Atlantic City Goldfield, Crook's Gap, Muddy Gap, Carbon Coalfield, Diamond Field (Colorado), Lost Soldier Oilfield, The Rim and Hoback Basin, Bison Basin Fossil Area, Shotgun Butte Fossil Area, Twin Buttes Fossil Area, Beaver Rim, Boar's Tusk, Rattlesnake Hills, Red Canyon, Bates Hole, Continental Peak and Oregon Buttes, Devil's Gate, Split Rock, Hell's Half Acre, Sand Creek, Flaming Gorge, Pinedale and Bull Lake, Grizzly Buttes, Big Hollow, Killpecker Sand Dunes, Washakie Basin, Fortification Dike, and Little Box Elder Cave.

# # #

THE ECOLOGY OF THE BEAVER (*CASTOR CANADENSIS*) ON THE SNAKE RIVER FLOODPLAIN

INVESTIGATOR:    Thomas C. Collins  
                         University of Wyoming

SUMMARY OF PROGRESS: This project will not be officially initiated until May 1974. However, some preliminary investigations were carried out in July 1973. These involved observations of beaver activity and behavior in the park. The study area comprises the Snake River and its major tributaries from Jackson Lake Dam to Moose. Within this area a total of 32 active or abandoned beaver dwellings was located and mapped during July 1973. Additionally, preliminary data were collected regarding food habits, habitat utilization, and relationships with other animals utilizing the floodplain habitat.

Future work will progress as anticipated, that is, the ecology of the beaver will be approached in relation to the uniqueness of the park, protection of both habitat and the study animal, and human usage of the park for recreational purposes. Beaver habitat utilization and modification will be analyzed from a historical point of view due to the availability of aerial photographs of the floodplain from years past. This information combined with data to be gathered in the next few years will hopefully lead to an interpretation of the cyclic nature of beaver activity on the floodplain.

Support level adjustment may be necessary for travel and aerial photography. This additional funding which may be necessary will be requested from the Welder Wildlife Foundation and the Roosevelt Memorial Fund.

Further information on this project or the project proposal is available from the investigator or Charles McCurdy, Grand Teton National Park, Wyoming.

# # #

#### NUTRIENT LIMITATION OF AQUATIC PRIMARY PRODUCTION IN GRAND TETON NATIONAL PARK

INVESTIGATOR: Michael Parker  
University of Wyoming

SUMMARY OF PROGRESS: All field and laboratory work has been completed. Additional analysis of data remains to be done before completion of a final report.

SIGNIFICANT FINDINGS: In bioassays with *Selenastrum capricornutum*, phosphorus (0.005 to 0.05 mg P l<sup>-1</sup>) always significantly increased algal standing crop over Jackson Lake controls, while nitrogen (0.01 to 0.05 mg N l<sup>-1</sup>) did on some occasions. Other nutrients were not evaluated.

Surface waters of Jackson Lake directly exposed to the stress of the wind were very quickly transported downwind. Some Snake River water entering the north end of the lake in late June/early July followed the bottom of the lake in the old river bed. It apparently mixed little with epilimnetic water, at least until some distance south of Wilcox Point. Water from Third Creek also followed the old creek bed until reaching a portion of the lake directly exposed to the wind. At that point it moved downwind.

Addition of phosphorus or nitrogen to Jackson Lake should stimulate algal growth. If added at a location where wind action would not transport and dilute the nutrients in open water, relatively small amounts might cause changes noticeable to the untrained eye. If brought into the lake by the Snake River, the shallower northern end of the lake (north of Fonda Point) could be likewise affected. Larger amounts might be transported along the old Snake River bed and affect the epilimnion south of Wilcox point.

Nutrients entering Jackson Lake via Third Creek would affect the bay where the creek enters the lake. Because of prevailing winds, it would also quite likely affect the shallower region of the lake east of the creek and north of the dam.

Additional calculations need to be made before "small amounts of nutrients," etc., can be estimated in terms of absolute rates of nutrient input.

# # #

## CLIMATOLOGICAL STUDIES FOR THE YELLOWSTONE-TETON NATIONAL PARKS

INVESTIGATOR: Richard A. Dirks  
University of Wyoming

SUMMARY OF PROGRESS: Data collection, error correction, and smoothing for missing data have been completed for the 30-year period, 1941-70, for the 16 stations in the parks area. Climatological normals have been obtained for several of these stations.

Collection of historical records of published data has been largely completed. Historical records of site descriptions for climatological stations have also been assembled and are near completion. A considerable effort has been expended in seeking out data collected in special studies in the parks and their vicinity. To date, only a small amount of data has been derived from such studies. Preliminary examination has also been made of short-term and intermittent data, e.g., fire, weather observations, snow surveys.

It is evident that several major gaps exist in climatic data for the parks:

- a. Complete records exist only for stations located at low elevations in the parks. Observations are very sparse for the vast, higher elevation, exposed regions of the parks.
- b. Detailed wind data are limited to several stations outside the parks boundaries. Within the parks, data are scarce and existing data are quite seasonal.

## GREAT SMOKY MOUNTAINS NATIONAL PARK

### ANAKEESTA ACID POLLUTION STUDY

INVESTIGATOR: Dennis B. Fenn  
National Park Service Science Center

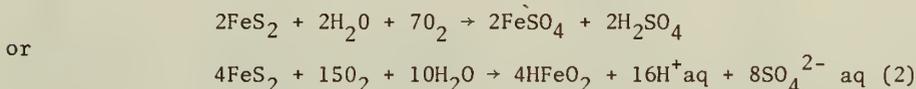
OBJECTIVES: To determine the extent and degree of the problems of acid leaching from anakeesta pyrite deposits that have been disturbed by road construction in the park, and to devise feasible methods for controlling this problem as close to the source as possible.

METHODS: Samples of the anakeesta pyrite were obtained from the Newfound Gap roadfill, the source of a highly acid leachate that has caused a massive fish kill in a 3-mile stretch of the stream below the roadfill (Huckabee et al. 1974). This rock was broken into 3-inch chunks and placed in laboratory leaching columns made of

PVC sewage line 5 ft long and 4 inches in diameter. Distilled water was slowly dripped into the column and allowed to percolate down through it. The columns were designed to then feed the leachate into a 500-ml trap where the water could be sampled or fed into a treatment column. The treatment column was a similar pipe but only 3.5 ft in length. The initial treatment column was filled with a 60-40 mixture of sand and dolomitic limestone.

RESULTS AND DISCUSSION: Table 1 shows the results of the initial studies with the leaching columns. As can be seen, the pH of the water, which was initially 7.4, drops to as low as 3.58 during percolation through the sulfide-enriched anakeesta pyrite material. As shown in Table 1, the limed sand is very effective in neutralizing the acidity and removing the high levels of  $\text{Fe}^{3+}$ ,  $\text{Mn}^{2+}$ , and  $\text{Al}^{3+}$  from the water. The  $\text{Ca}^{2+}$  and  $\text{Mg}^{2+}$  levels increase, however, as would be expected from the limestone-sand mixture.

The action of the sulfide-enriched pyrite mineral in water is the oxidation of the pyrite to sulfuric acid. Two possible chemical reactions that are occurring are listed below:



It is interesting to note that both reactions result in the production of sulfuric acid and require the presence of oxygen. It is only when the anakeesta deposits have been disturbed through road construction or natural stream erosion and exposed to the air that this acid pollution problem has occurred.

PLANS FOR 1974: The laboratory leaching studies are being expanded and will be continued in an effort to determine the best controlling treatment to rectify or prevent this problem. A proposal has been submitted for funding to install three satellite-associated data collection platforms on site in the Great Smoky Mountains National Park to monitor the seasonal fluctuations in this acidity problem and to gather data that will be of use in solving this serious enigma.

#### Publications:

- Huckabee, J. W., C. P. Goodyear, and R. D. Jones. 1974. Acid Rock in the Smoky Mountains: An unanticipated impact of road construction on aquatic environments. (In Press)
- Handbook of Geochemistry: Volume 2. K. H. Wedepohl, executive editor. Springer-Verlag Berlin. New York. 1970. page 26-G-2.

Table 1: Analysis of the leachate after percolating through the anakeesta rock column and after percolating through the treatment column.

	Anakeesta Leach	Sand- Line Leach	Anakeesta Leach	Sand- Line Leach	Anakeesta Leach	Sand- Lime Leach
	1	2	3	4	5	6
pH	4.50	7.75	3.58	7.22	3.9	7.1
Cation	PPM					
Cu	0.08	0.02	0.05	ND	ND	ND
Mn	2.73	ND	4.28	ND	0.72	0.01
Ni	0.19	ND	0.20	0.12	ND	ND
Co	0.24	0.02	0.19	ND	0.08	0.08
Ca	0.74	210.0	0.68	240.0	0.40	101.0
Mg	3.30	30.0	5.90	11.20	0.81	6.50
Fe	31.0	0.10	17.90	0.10	1.60	ND
Zn	0.31	0.27	0.33	0.29	0.04	0.06
Na	230.0	52.5	9.0	17.8	15.5	30.0
K	0.20	2.35	0.24	0.29	0.15	0.17
Al	5.10	ND	4.20	ND	0.42	0.15

# # #

### MIMOSA WILT: CONTROL OF PLANTS THROUGH NATURAL DISEASE

INVESTIGATOR: Donald E. Gardner  
National Park Service Science Center

OBJECTIVES: To employ a natural disease in devising a practical control method for mimosa (*Albizzia julibrissin*) trees in national park areas.

METHODS: Isolates of the fungus *Fusarium oxysporum* f. sp. *perniciosum* taken from dying mimosa trees were cultured on Potatoe Dextrose Agar. Spore and mycelial suspensions were obtained by homogenizing the cultures in a blender. Trees were inoculated by various methods through the roots and the stems. Cut branches were dipped in inoculum, inoculum-dye solution was injected into xylem tissue by various methods, mistures of inoculum and sand-corn meal were placed in holes dug near trees, and seedlings were removed from their growth medium and their roots dipped in inoculum.

RESULTS AND DISCUSSION: Seedlings whose roots were dipped in spore suspension showed severe symptoms of mimosa wilt within 14 days after the treatment. The seedlings subsequently died. None of the other treatments attempted have yet yielded symptoms which could definitely be attributed to the mimosa wilt organism, although observation is continuing

Inoculum and dye solutions injected at pressures approaching 300 psi into roots and stems of trees removed from the soil were forced up to approximately 38 inches through the xylem tissue. Inoculum recovered at this distance was found to be viable. Further

investigations will test the success of similar inoculations made in intact trees. Determination will be made of the extent to which the root system must be invaded by the fungus in the form of the above-described inoculum for disease symptoms to result.

## GUADALUPE MOUNTAINS NATIONAL PARK

### WATER RESOURCES OF DOG CANYON (UPPER)

INVESTIGATOR: Dustin M. Aughenbaugh

OBJECTIVES: To appraise the water resources of Upper Dog Canyon with particular emphasis on the availability and suitability of the ground-water resources.

METHODS: Compile all available geohydrological and geological studies, data, and information of the immediate and surrounding area; extend the depth of the existing 350-ft test well for local verification of the character of the area; and prepare a comprehensive water resource report.

RESULTS: An investigation of the water resources for Upper Dog Canyon resulted in little or no dependable supplies of surface water being available. Flow from seepages and springs range less than 1.5 gpm (estimated) and wildlife depends on these supplies. The only runoff supply, located northwest of the Ranger's Station, is intermittent and undependable, being runoff from the local rainfall. Back in the 1960s, a 500-ft test well was drilled on the west side of the canyon about 0.25 mile south of the Ranger's Station; the exact location is unknown. The well tested the alluvium and the Goat-Seep Limestone, but failed to obtain any water. The present test well is being drilled to 1300 ft into the Goat-Seep Limestone on the east side of the canyon. As of this date (January 1974), the depth is 970 ft with little or no water encountered. However, according to data from Spiegel Well No. 1, the regional water level in this area is just below 1000 ft where a probably adequate water supply may be available. The Spiegel Well, drilled as an oil well some distance north of Dog Canyon, was converted into a 1200-ft water well and provides sufficient quantities (est. 20-60 gpm) of low-mineralized water (sulfates less than 250 mg/liter). However, the water is reported undesirable as drinking water due to possible contamination by the oil well casing.

CONCLUSIONS: The data that are available indicate that a well drilled into the regional water table is the most likely source of water.

PLANS FOR 1974: Continue to drill the present test well to 1300 ft into the regional water table of the goat-seep limestone formations.

#### Bibliography:

- Pratt, Wallace E. 1971. A report on Guadalupe Mountain National Park. A report to Edward R. Leggat.
- Leggat, E. R. 1972. Test Well in Pine Canyon. A memorandum report of 26 May 1972 on water resources of Pine Canyon and Dog Canyon.

WATER RESOURCES OF GUADALUPE MOUNTAINS NATIONAL PARK, TEXAS

INVESTIGATOR: E. R. Leggat  
U.S. Geological Survey

OBJECTIVES: To appraise the water resources of the Guadalupe Mountains with particular emphasis on the availability and suitability of the ground-water resources.

METHOD: The study included a complete inventory of all sources of water in and adjacent to the park, drilling and pumping of test wells, and preparation of a comprehensive report by the U.S. Geological Survey.

RESULTS: The investigation of the water resources of the park was temporarily halted in 1972 due to the lack of funding. The results through 1972 included a complete inventory of all the sources of water and the testing of a well on the west side of the park. In 1973, an uncased 750-ft test well was drilled into the edge of the Capitan Reef near Frijoles Springs. In general, the basin deposits fronting the Capitan Reef yield only small quantities (less than 5 gpm) of water that commonly is too highly mineralized for public supply use. On the other hand, the alluvium along McKittrick Draw yielded sufficient quantities (20-100 gpm) of good quality water. In the western and southwestern parts of the park, bolson deposits and the Capitan Reef yield large supplies (as much as 300 gpm) of water but the sulfate and chloride content exceeded the limits recommended by the U.S. Public Health Service for public supply. The flow of several springs in the vicinity of Frijoles ranged from less than 10 gpm to as much as 50 gpm, but wildlife depends on at least a part of these supplies. McKittrick Creek, the only surface stream in the park, had a flow of 328 gpm near the mouth of the canyon, where the water goes underground.

CONCLUSIONS: Data available indicate that the alluvial deposits in McKittrick Creek are the most likely sources of good quality water in the park. The Frijoles well, which is incomplete, has a possible yield of 10 gpm as determined by data obtained from 10 hours of bailing.

PLANS FOR 1974: Complete the Frijoles well by logging and casing the bore and pump testing the aquifer. Evaluate test well drilling at or near the mouth of McKittrick Canyon.

Bibliography:

- Leggat, E. R. 1969. Preliminary report on the water resources of the proposed Guadalupe Mountains National Park, Texas. U.S. Geological Survey open-file report, 28 p., 2 figs.
- . 1971. Results of aquifer tests at Guadalupe Mountains National Park. U.S. Geological Survey memorandum report.
- . 1973. Water resources of Guadalupe Mountains National Park. U.S. Geological letter report.

# # #

SURVEY OF THE VASCULAR PLANTS, GUADALUPE MOUNTAINS NATIONAL PARK, TEXAS  
GUMO-N-013

INVESTIGATOR: David K. Northington  
Texas Tech University

SUMMARY OF PROGRESS: The survey of the vascular plants of the Guadalupe Mountains National Park (hereafter referred to as "the park") was initiated on 1 June 1973. The proposed work to be accomplished during the first year included extensive field collecting in all areas of the park and a thorough review of pertinent literature. This progress report for the first 7 months of the project will include a brief review of the literature examined and how this material relates to our efforts and a progress check list of plant taxa thus far identified from this summer and fall's collecting. For the latter, comments concerning rare endemic and/or taxa of restricted distribution will be presented. In addition, several systematic research problems have been realized from the park survey and will be briefly discussed.

The available literature on the park pertinent to this study falls into two basic categories, plant checklists and vegetative zone type publications. For this year's work, the checklists are more important in that they provide a basis on which to compare the number, locality, and relative occurrence of taxa reported from the park. Certain of these checklists in fact specifically enumerate only the rare or endangered taxa reported for the park. The reports that deal primarily with vegetative zones or plant communities in the park are quite thorough, especially for the lower elevations and main canyons. Our field notes, observations, and distributional ranges are compiled with an awareness of these previous studies as a starting point and future work for the remote sensing portion of the project will further incorporate these accumulated data. Much of this work is dependent on the availability of a high altitude, infrared photograph of the park which should be forthcoming in the near future. At that time, specific homogeneous and heterogeneous vegetative zones can be specifically examined for dominate and associated plant taxa and then used to extrapolate the vegetative make-up of other areas. These extrapolated communities can then be checked for reliability of the program and all plant community data can be correlated with the small mammal-vegetation associations being established by Dr. Baker and Genoways.

To date, all but two major areas of the park have been collected and most areas have been visited two to four times at different times during the past summer and fall. The early spring flora has not yet been collected and this will be the first priority next spring (1974).

# # #

#### STUDIES IN VASCULAR PLANTS, MAMMAL SURVEY, AND DATA ANALYSIS GUMO-N-013

INVESTIGATOR: Benjamin S. Duran  
Texas Tech University

SUMMARY OF PROGRESS: A significant amount of time in the initial phase of the GMNP study, relative to the computer and data analysis aspects, has been spent in establishing contacts with other parties regarding the existence and availability of computer software, and in reviewing and evaluating such computer software to determine its usefulness in the GMNP study. Other activities related to the computer aspects of the GMNP are summarized below. A more detailed statement of the total involvement is included in the annual report.

- (1) A list of guidelines that could be followed in attempting to develop an operations management system for GMNP were outlined.
- (2) Correspondence was opened with other groups involved in similar types of studies.
- (3) It was determined that a satisfactory coordinate system for GMNP would be one consisting of 100 m units, that is, plots of size 10,000 m<sup>2</sup> (approximately 2.5 acres).
- (4) A flyover for acquiring various types of aerial photographs of GMNP was requested (17 July 1973). These photographs will be interpreted at Texas Tech University when they are received.
- (5) An ERTS data tape of the GMNP area was requested (August 1973). This data tape

will be analyzed using the appropriate computer programs. The utility of this data relative to low flight data for the purpose of monitoring the park will be investigated.

- (6) A computer program on physical, biological, and cultural resource data describing GMNP is being developed.

At present the development of the computer software (including (6) above) is, roughly, 50% complete. The intent, for the present, is to utilize for the most part the vegetative and cultural resource data of GMNP.

Looking ahead, efforts will be made to interact the computer aspects involving the vegetative data with information involving the data on the mammals of GMNP. By surveying the changes and characteristics of various habitats, useful information about specific mammals can be obtained. For example, it may be possible to study the movement of the mammals within the park by studying the changing environment.

# # #

SURVEY OF THE MAMMALS OF THE GUADALUPE MOUNTAINS NATIONAL PARK, TEXAS  
GUMO-N-013

INVESTIGATORS: Hugh H. Genoways) Texas Tech University, The Museum  
Robert J. Baker ) Texas Tech University

SUMMARY OF PROGRESS: The objectives of this study were to survey the mammals occurring in the Guadalupe Mountains National Park, Texas, and to correlate the distribution of the individual species with major plant associations. Also, data on the relative abundance of mammalian species within each plant association were to be obtained. Subsequent to the initial survey, three live-trap grids are to be studied to obtain data on population sizes, population turnover, and secondary productivity. When data from both portions of this study have been correlated with the plant data being collected in the park, it should be possible to monitor gross changes in distributional patterns of the mammals, using remote sensing. Remote sensing should be able to detect changes in plant communities, which will in turn indicate changes in the mammalian communities associated with them. These data can be used to monitor human impact in the park and thus aid in management planning for the Guadalupe Mountains National Park.

SIGNIFICANT FINDINGS: At the beginning of this study 35 species were known to have been reported from the Guadalupe Mountains. Our survey work has confirmed the presence of 51 species of mammals in the Guadalupe Mountains National Park. Seven additional species are known to have occurred in the area previously and now have been extirpated. Eight other species are suspected to occur in the park, but we have not obtained specimens at the present time.

A number of significant ecological and systematic problems have been identified in our first year of work that are still being studied. One problem that is being studied by John Cornely for a Master's thesis is the ecological relationships of the three species of *Neotoma* occurring in the Guadalupe Mountains National Park. Peggy O'Connell is studying the relationships of *Dipodomys merriami* and *D. ordii* in the park. An in-depth understanding of the relationships of the species in both of these studies offer promise as possible monitoring systems that could be used in park management. Dallas Wilhelm is studying the ecological and systematic relationships of *Microtus mexicanus guadalupensis* for a Ph.D. dissertation. This taxa was listed as "status-undetermined" in the 1973 edition of the Threatened Wildlife of the United States published by the U.S. Department of the Interior. Any management plan for the park should consider the status of this taxa.

NATURAL ECOLOGIC CONDITIONS-FIRE  
GUMO-N-009

INVESTIGATOR: Gary M. Ahlstrand  
National Park Service

SUMMARY OF PROGRESS: This study will run concurrently with CACA-N-11a, Natural ecologic surface conditions--Part A: Wildfire.

Old natural burn sites are being sought so that permanent plots can be established in order to follow successional trends. Three of these sites have been located in the park to date.

Approximately half of the equipment needs for the study have been requisitioned, but not yet received.

Reasons for the growth of dense stands of "dog-hair" tree seedlings and saplings in The Bowl are being sought. This information is needed so that a realistic management policy for the area can be formulated, especially with regard to fire. A size class distribution and dating study of trees in The Bowl is about 80% complete. Results from this study are being compared with the grazing history and past climatic records as both become available. Thus far the ages of these young stands correlate quite well with exceptionally wet years after the introduction of stock into the area.

It is hoped that during the first quarter of 1974 that equipment can be purchased and constructed so that the study can be well under way during the second quarter.

# # #

NATURAL ECOLOGIC CONDITIONS: METEOROLOGY STUDY  
GUMO-N-009

INVESTIGATOR: Gary M. Ahlstrand  
National Park Service

SUMMARY OF PROGRESS: Equipment for three complete weather stations has been selected and ordered. The stations will monitor continuously for 31-day periods the following: wind speed and direction, precipitation, temperature, relative humidity, and shortwave radiation. A fourth wind-monitoring set was ordered to act as a portable unit.

SIGNIFICANT FINDINGS: Equipment has not been received to date, thus no findings.

RECOMMENDATIONS: It is planned that NPS personnel will install, operate, and maintain the stations for at least the first year, using an outside consultant for analysis of the wind data. After the completion of the first phase of the study, it is anticipated that the equipment will be loaned to Texas Tech personnel for the continuation of the study in other portions of the park (under GUMO-N-13).

LOCATION AND INVENTORY OF CAVES  
GUMO-N-099

INVESTIGATOR: Charles M. Peterson

SUMMARY OF I have continued to systematically examine backcountry areas of the park  
PROGRESS: caves. Five new caves have been added to the park files, making a total  
of 15 known caves. Of these 15, I have visited and inventoried 11. I  
have spent about 15% of my work on this ground reconnaissance.

I have arbitrarily set a 5-year time span for the ground reconnaissance and inventory of caves. During these years I will extensively cover the Guadalupe backcountry; however, one can be assured that new caves will continue to be found after this project, due mainly to the extreme ruggedness of the park.

# # #

INTERAGENCY BROWSE RANGE ANALYSIS SURVEY  
GUMO-N-099

INVESTIGATORS: Mike Glass  
Roger Reisch

SUMMARY OF Field work completed and analysis of data started; estimated 10%  
PROGRESS: finished but not in a recordable form.

SIGNIFICANT Rare plants found and locations noted on topographic map. Areas of  
FINDINGS: heavy deer and elk use observed and recorded. Various wildlife species  
observed and recorded, e.g., one *Javelina*.

RECOMMENDATIONS: Too early to make any recommendations now without further analysis  
of data. I will not have enough time to do analysis of any great  
extent due to time shortage.

# # #

COMPOSITIONAL ASPECTS OF BREEDING AVIFAUNAS IN SELECTED WOODLANDS  
OF THE SOUTHERN GUADALUPE MOUNTAINS, TEXAS  
GUMO-N-012

INVESTIGATOR: George A. Newman  
Texas A & M and Hardin-Simmons universities

SUMMARY OF The manuscript entitled Recent bird records from the Guadalupe Mountains,  
PROGRESS: in Texas is scheduled to be published early in 1974 in *The Southwestern*  
*Naturalist*.

My research in the summer of 1973 turned up additional records of considerable interest. Among these were the discoveries of a breeding pair of Plain Titmice, five juvenile Saw-whet Owls, and a Worm-eating Warbler. Peregrine Falcons once again nested in the upper South McKittrick Canyon area.

Data on bird densities were collected on my census plots in McKittrick Canyon (main, south, and north), Upper Dog Canyon, and The Bowl. A few returns of banded birds from previous years were recorded. Limited collecting of selected species was accomplished.

The summer of 1974 will draw to conclusion this phase of my research. I need to be in GMNP from about 20 May to 1 July 1974. I will follow the same procedure as in the summers of 1972 and 1973 with approximately 2 weeks spend in each location: McKittrick, Upper Dog, and The Bowl, respectively. Funding has been granted by Welder Wildlife Foundation for 1974.

A checklist of birds for GMNP is now in preparation and should be available for the park by April 1974.

## HALEAKALA NATIONAL PARK

### HAWAIIAN GOOSE "NENE PARK" PLAN HALE-N-0010

INVESTIGATORS: Haleakala Park Staff  
Dunatchik, Kokubun, Kuailani

SUMMARY OF PROGRESS: The nene breeding pens have been built as well as a release pen. Of two pairs of nene bred in 1972-73, one pair raised five goslings. In 1973-74 (so far) both pair of nene have nested, and one pair now has three goslings.

SIGNIFICANT FINDINGS: The five goslings raised in 1973 were released into the wild and four have survived and been seen in the vicinity of the release site. No conclusions can yet be made.

RECOMMENDATIONS: The project should continue until the status of released birds can be determined.

# # #

### PRESERVATION OF THE DARK-RUMPED PETREL HALE-N-0006

INVESTIGATORS: Haleakala Park Staff  
Kunioki, Kokubun, Dunatchik

SUMMARY OF PROGRESS: Since Warren King's research reported in 1971, yearly summer censuses of petrel burrows have been conducted by the park staff. Activity still centers on the west crater pali. Predator trapping near the nesting sites continues from February through October.

SIGNIFICANT FINDINGS: A total of five rats were caught in 1973 near the nesting area. Predation was very small this year with signs of only four burrows being raided. Nine new active burrows were discovered, but total active burrows were only 76% of total burrows visited. This is down slightly from last summer when 81% of the burrows visited were active.

Three dead petrels were found this summer. Two were found outside the nesting area.

RECOMMENDATIONS: Continue annual census and trapping programs.

# # #

### THE GEOLOGY OF HALEAKALA CRATER HALE-N-0001

INVESTIGATOR: Gordon A. Macdonald  
University of Hawaii

SUMMARY OF PROGRESS: This work is carried on on a part-time basis, as time and funds permit. Thus far, the mapping of the crater and west slope are essentially completed, on a scale of 1:12,000. Thin sections of approximately 80 rock samples have been studied, and study of additional ones is continuing. The final map of the crater is being assembled, correlating the field work with the thin section study. The thin section work has been supplemented by four new chemical analyses. The new mapping is on a larger scale than that done in the 1930s and early 1940s, and in addition will show rock types as well as geologic age, whereas the earlier mapping showed only age. Thus far the field work demonstrates that the plant cover is influenced far more by the general layer of surficial ash than by the type of the underlying rock.

The work should continue as planned, as time and funds permit.

# # #

### ECOLOGY OF THE SILVERSWORD HALEAKALA CRATER, HAWAII HALE-N-3

INVESTIGATOR: Herbert K. Kobayaski  
University of Hawaii

SUMMARY OF PROGRESS: *Argyroxiphium sandwicense* DC. is an endemic composite of the alpine zone in Hawaii. Western man and his herbivores have restricted its present distribution mostly to the cinder cones and lava flows within Haleakala Crater, Maui. Here the silversword is able to sustain a high regeneration rate under dynamic substrate conditions that eliminate all but a few exotic and endemic species.

Long-term field measurements of environmental parameters and growth cabinet experiments on germination and seedling survival established the following optimal conditions. Germination and seedling survival depend on a temperature not exceeding about 30°C, and the relatively high moisture content of a stable sandy substratum completely covered by cinder fragments no thicker than about 5 cm. The maintenance of the thin, complete cover over an area larger than a hectare for a period of a few decades is best met by a shelf of agglutinates supplying tabular fragments which slide over a sloped, sandy germination layer. The slope angle is about 35°; low enough to stabilize the sandy layer,

yet steep enough to be slightly unstable for tabular fragments. A thin cover is maintained by removal of fragments at the foot of the slope by wind and water during winter storms.

Vandalism and browsing are probably not important under the protection of the National Park Service, but root breakage by trampling may become a problem with further increase in visitors. Seed damage by insects may not be important as previously reported, but confirmation awaits further investigation during a good flowering season.

## HAWAII VOLCANOES NATIONAL PARK

### THE STATUS OF BIRD POPULATIONS IN HAWAII VOLCANOES

INVESTIGATOR: Paul C. Banko  
National Park Service

OBJECTIVES: Numerous bird species in Hawaii and Hawaii Volcanoes have gone extinct due to several probable causes. Numerous other species are threatened with extinction and are listed as rare and endangered species. Population studies of park birds were conducted in the 1940s and 1950s. It is of interest now, in the 1970s, to see how populations compare with the earlier censuses in order to evaluate to current trends and status of park populations.

METHODS: Efforts were made to locate exactly the earlier census areas so that 1973 studies would overlap them in area, size, and time devoted to each census per visit. The goals of the censuses were to determine relative occurrences and relative abundances of each species per each census area covered.

RESULTS AND DISCUSSIONS: Of seven native and eight nonnative birds surveyed, two native species, the Creeper (*Loxops maculata*) and the Akiapolaau (*Hemignathus wilsoni*), are no longer found in the park. Two other native species, the Amakihi (*Loxops virens*) and the Apapane (*Himatione sanguinea*), seem to be maintaining former levels of relative occurrence.

One native species, the Elepaio (*Chasiempis sandwichensis*) has disappeared from some areas of the park and decreased only in others. The native Iiwi (*Vestiaria coccinea*) has had a drastic overall decrease in numbers. The native Omao (*Phaeornis obscura*) is declining in lower elevations but is increasing in higher elevations.

Of the nonnative passerines in the park, the Leiothrix (*Alauda arvensis*) have decreased in relative occurrence. The Ricebird (*Lonchura punctulata*) and the House Finch (*Carpodacus mexicanus*) have retained their former levels of abundance. The Cardinal (*Richmondia cardinalis*) has increased at mid-elevations while the Japanese White-eye (*Zosterops japonica*) has increased at lower elevations and maintained equivalent levels at mid- and higher elevations.

## REESTABLISHMENT OF THE NENE (HAWAIIAN GOOSE) IN HAWAII VOLCANOES

INVESTIGATOR: Donald W. Reeser  
National Park Service

OBJECTIVES: The native Hawaiian Goose, or nene (*Branta sandvicensis*) is an endangered species. Wild breeding populations are now absent from the park although historical records reveal that much of the lowland park below 3000 ft was original nene range. Destruction of native habitat by nonnative ungulates and introductions of predator animals such as rats, mongooses, housecats, and dogs have apparently caused extinction of nene from former lowland habitats.

If habitats can be restored, however, through feral ungulate control, reforestation projects, and control of predators, the nene may be able to reinvade its former ranges within the park. This would be hastened by this special project of using captive, wing-clipped birds in special breeding enclosures.

RESULTS AND DISCUSSION: In August 1972, a 1-acre enclosure was constructed at the 2500 ft elevation and a pair of nene was released inside. In August 1973, a second larger enclosure was built about a mile distant at the 3000 ft elevation and a pair of nene was released inside on 1 November. As of 1 January 1974, there have been no successful breeding or nesting attempts made by either pair.

Inventories were made in both pens of the exotic and native vegetation present and numerous plantings were made of native species. A predator control program was initiated around each pen. A subsequent study of the vegetation reveals that succulent native plants are preferred and that exotic vegetation, established in the wake of decades of heavy goat and cattle browsing, is not preferred.

The results of the enclosures to date show that adult nene can survive in lowland elevations although successful nesting has not yet been demonstrated. Other pens are programmed for FY 1974 and the study will continue indefinitely. It is hoped in time that transplanted nene into the park will readjust to former habitats and that successful nesting will reestablish the species in former ranges.

# # #

## THE BIOLOGY OF THE ENDEMIC PLANT SPECIES *HIBISCADELPHUS* *GIFFARDIANUS* ROCK IN HAWAII VOLCANOES

INVESTIGATOR: James K. Baker  
National Park Service

OBJECTIVES: The hibiscus-like species (*Hibiscadelphus giffardianus* Rock) (family Malvaceae) is one of several plant species endemic to Hawaii Volcanoes. It was discovered in 1911 from a single known tree. The one tree died in 1940 but not before cuttings were obtained which eventually resulted in survival of eight of these trees now growing in Kipuka Puauulu, the type locality within Hawaii Volcanoes.

The species grows as a small, shade-tolerant tree up to about 30 ft in height under canopies of taller, native species. Its decline to the single tree before discovery was due, most likely, to the bark stripping habit of nonnative cattle, goats, and pigs which have abounded in Hawaii for nearly 200 years. Many succulent, soft-barked native species became extinct or were threatened with extinction due to this feeding habit of ungulates.

The species also blooms with a long, curved, tubular corolla which is atypical of the open corollas of other hibiscus or hibiscus-related species. This phenomenon is believed to be an evolutionary adaptation in coevolution with the long, curved-billed Hawaiian Honeycreepers, some of which are now extinct and which fed largely on nectar.

The tree species *Hibiscadelphus giffardianus* is, therefore, of value from three points of interest to the National Park Service at Hawaii Volcanoes: (1) it is an exceedingly rare endemic to the park which helps document the evolutionary history of species formation in Hawaii; (2) it helps document the role of extinction to native plants caused by the impact of nonnative animals in Hawaii and the park; (3) it is a species that was probably of major importance to honeycreeper birds in support of a theory that loss of food supplies was one of several major causes for the decline and/or extinction of these rare, native birds.

RESULTS AND DISCUSSION: In addition to the species *H. giffardianus* which is endemic to the park, another species (*H. hualalaiensis* Rock) was introduced into the park several years ago from another part of the same island. This was an effort at that time to save the species, now known from only three wild trees, from the ravages of cattle. There are ten of these trees now surviving within the park but they were, unfortunately, planted in the same Kipuka Puauulu with *H. giffardianus*.

The two tree species, unknowing to resource managers, produced hybrid seed which were collected for a greenhouse propagation program to grow additional trees of the endemic species *H. giffardianus*. Several hybrid trees are now growing and blooming within the park. It was just noted in 1973 that the trees were, indeed, hybrids and a description of the hybrid is being written by the investigator.

In a study of the hybrid situation it was noted for the first time that flowers of *H. giffardianus* contain considerable quantities of nectar which has so far been shown to be approximately three times more nectar per flower than any other native flower so far analyzed. The nectar is also rich in sugar and it has been shown also to be the richest nectar in amino-acids of any other native flower so far analyzed. In addition, it has been learned that the trees bloom daily during all months of the year thus providing continual sources of nutrients for honeycreeper birds.

Studies are to continue in the biology of the species and the relationships to native honeycreepers but from the data already available it is apparent that *H. giffardianus* is, or was, an important tree species to the native birds. The almost total loss of *Hibiscadelphus* species and other important trees by the ravages of ungulates may very well have played an important role in loss of the honeycreepers.

# # #

IMPACT ANALYSES OF EXOTIC MAMMALS UPON NATIVE HAWAIIAN ECOSYSTEMS  
HAVO-N-4b

INVESTIGATOR: James K. Baker  
National Park Service

OBJECTIVES: Nonnative mammals in Hawaii such as feral pigs and goats are scattered widely throughout the park. Research is underway on the life histories, numbers, distribution, and ecological impact of these animals to give the National Park Service necessary data for formulation of management programs and support data to help coneract hunter and political pressure groups in Hawaii that wish pigs and goats left in the park for hunting purposes.

RESULTS AND DISCUSSION: During 1973, research was conducted into the fortuitous role of feral pigs in the spread of mosquito populations throughout the rain forest sections of the park. The shallow, porous lava soils do not ordinarily pond rain water long enough to support breeding populations of mosquitoes. However, in localized areas where pigs repeatedly use the same small spot of ground for mud wallows to free themselves of hog lice, the compaction of the soils create muddy catchment basins which hold rain water for weeks at a time. Mosquito larvae can be found in these wallows during all months of the year.

The pig also has a habit of hollowing out the pithy interiors of tree ferns in order to feed on the starchy pulp inside. These hollows also collect rain water and support mosquito populations. In a 1-hectare study plot there are 35 tree fern hollows supporting mosquito populations, a plot that would contain no mosquito habitat were it not for the pig.

There were no mosquitoes in Hawaii before 1826 when they were accidentally imported into the islands from a ship carrying water barrels containing larvae. The mosquito subsequently became the vector for spread of avian malaria and birdpox which had also been introduced with introductions of nonnative birds. It is believed that one of several major causes for the decline and/or extinction of many of Hawaii's endemic birds has been due to the spread of bird diseases by mosquitoes.

If we can demonstrate that the pig is a major contributor to mosquito populations and that mosquitoes in turn are one cause of native bird decline, the National Park Service will have overwhelming evidence against the pig (in addition to other data on damages to native plants, etc.) within Hawaii Volcanoes and in defense of management programs aimed at eliminating the pig from the park.

## HOT SPRINGS NATIONAL PARK

### EFFECTS OF URBAN DEVELOPMENT ON THERMAL SPRINGS IN HOT SPRINGS NATIONAL PARK

INVESTIGATORS: M. S. Bedinger            C. G. Stone            )  
                  J. E. Reed                P. W. Westerfield)    U.S. Geological Survey  
                  F. J. Pearson             )

OBJECTIVES: The National Park Service is at present making long-range plans for the future use and development of Hot Springs National Park. The questions raised by the planners may influence drastically what can be done and where: What effect will development, particularly on the lower slopes of Hot Springs Mountain, have on the flow of Hot Springs? How important is the mountain/valley area immediately west of the present park as a recharge area or source of water for the springs? The study will define the hydrologic system of which the Hot Springs are a part. Also, an estimate of the effect of urban development on spring flow will be made.

METHODS: Collection of total spring flow; periodic measurements of individual hot springs and cold springs; chemical analysis of springs, as needed; and urban and rural land-use mapping. Classification of the hydrologic significance of urban and land-use factors, evaluation and revision, as necessary, of data-collecting

networks, reexamination of the concept of the Hot Springs ground-water flow system in light of recent data.

RESULTS AND DISCUSSION: Final report submitted.

CONCLUSIONS: The model provides the best inferred evidence of the nature and operation of the spring flow system. Tentative conclusions are that the water is heated by a locally high, abnormal geothermal gradient; the recharge area is in the Big Fork Chert outcrop northeast of the springs with limited recharge through the Arkansas Novaculite; the maximum temperature the water reaches while in the flow system is only a few degrees higher than that at which it issues from the springs; the temperature of the larger springs according to records collected to date is relatively constant, whereas the display springs show a temperature variation most likely due to atmospheric variation; the springs show a very pronounced variation in flow most likely due to changes in seasonal recharge.

PLANS FOR 1974: Continuation of monitoring program for total flow from all springs and spring-water temperature.

Bibliography to date:

Carbon-14 ages of water from the Arkansas Hot Springs. F. J. Pearson, Jr., M. S. Bedinger, and B. F. Jones.

The thermal springs of Hot Springs National Park, Arkansas - factors affecting their environment and management. M. S. Bedinger, R. T. Sniegocki, and J. L. Poole.

Talks on the Hot Springs given before civic and professional groups:

M. S. Bedinger - 2

R. T. Sniegocki - 3

## ISLE ROYALE NATIONAL PARK

### ECOLOGY OF SPRUCE FIR FORESTS

ISRO-N-1

INVESTIGATOR: Robert A. Janke  
Michigan Technological University

SIGNIFICANT FINDINGS: See reports submitted on 9 June and 20 October 1973.

ANALYSIS OF THE ISLE ROYALE ECOSYSTEM: MEASUREMENT AND SIMULATION OF THE FLOW OF ENERGY AND NUTRIENTS WITHIN THE VEGETATION-MOOSE-WOLF TROPHIC CHAIN

INVESTIGATORS: Peter A. Jordan )  
Daniel B. Botkin) Yale School of Forestry and Environmental Studies

SIGNIFICANT FINDINGS: Production of woody vegetation within reach of moose is 52 g/m<sup>2</sup> based on island-wide sampling. Of this, 13 g comprises preferred summer forage, and 8.2 g is acceptable winter browse. Moose are removing an approximate average of 7% of the summer browse and 46% of the winter browse. Summer browse removal is more critical to plants because it occurs during the growing season. The average removal does not reflect that preferred species are being harvested at rates substantially higher. Mountain ash loses around 40% of leaves in summer and as much as 90% twigs in winter to moose.

Intensive studies at the west end of Isle Royale during 1971-73 show that moose prefer mountain ash above all other species for summer browsing. While this species was the most frequent item in the 1972 diet, it was second in frequency in 1973. The decline is attributed to lower availability due to overuse. At the same time, mountain maple, the second most preferred, moved from second to first place in dietary frequency.

Moose feed extensively on aquatic macrophytes in beaver ponds, inland lakes, and bays. The time a moose keeps its head under water appears in part inversely related to the density of aquatic plants. The energetic cost of moving through a pond, hence foraging there, is many times greater than the cost of harvesting a like amount of energy during terrestrial browsing. Rate of intake, dry-weight/unit time, is approximately four times greater in forest browsing, and the energetic cost of walking through a beaver pond is approximately three times greater than on dry land. This suggests that moose are not taking aquatics as a general food source, but rather are selecting for some special factor not available on land.

Chemical analyses of plant and animal tissues indicate sodium is a critical nutrient for moose. This mineral is insufficiently available in terrestrial plants. Moose may overcome part of their sodium deficiency by using natural mud licks, but our measurements indicate the primary source is from aquatic plants. These plants concentrate sodium 30-900 times above the average for common browse plants. In 1973 we measured production and utilization of aquatics using simulated--grazing and enclosure--clipping techniques. Growth of aquatic plants continues in September after removals by moose have essentially ended; the residual growth is then fed upon by moose during the following spring before the new season's growth commences. This is important because moose must "store up" sodium over winter, and spring is the season when deficiency would be most sorely felt. Preliminary data indicate the rumen fluid is a site of sodium storage because sodium present there can be replaced by potassium when dietary intake of the former is inadequate.

# # #

RED SQUIRREL SUBSPECIATION IN THE LAKE SUPERIOR REGION  
ISRO-N-1

INVESTIGATOR: Donald E. Maki  
Michigan Technological University

SUMMARY OF PROGRESS: My Master's thesis was completed as of 16 June 1973. I was able to distinguish differences among the three subspecies studied.

BEACH TEXTURE OF ISLE ROYALE NATIONAL PARK, MICHIGAN

INVESTIGATORS: James P. Sullivan)  
J. M. Pezzetta ) University of Wisconsin

SUMMARY OF PROGRESS: Recently I spoke to Jim Sullivan concerning the status of the above project and I have been given to understand that he would like to continue with the proposed beach sediment sampling program during the coming summer (1974).

I first saw the report which he submitted to the L.E.S. office when he brought me the original just a few days ago. In reviewing the paper, I was quite impressed with the quality of work that Jim can perform when he applies himself to the task at hand. However, I had very little contact with him during the past academic year and from what I have been able to gather a number of personal problems have beset him, including illness. In view of the extenuating circumstances, I feel that he would like to step out of college for a while until he can establish a stronger economic base from which he would be able to complete his university education.

He mentioned that he would like to explore the possibility of working with the National Park Service on the island. While I am not aware of any openings for college students in this area, I do hope that he will be able to realize that goal. Perhaps this might be just the impetus needed to help him achieve some interim objective while he is contemplating his educational program.

In any event, it would be regrettable indeed if this project could not be completed. No one to my knowledge has ever undertaken such a detailed study of the textural characteristics of the island's beaches, and I know that this will be a significant contribution to the natural history of the island. The geological information in itself would be of inestimable value. Hence, I shall be prepared to provide whatever advisory services are necessary to complete the project and I look forward to a continuation of the spirit of mutual cooperation between the NPS and the University of Wisconsin-Green Bay.

Please feel free to contact me at any time if you would like any additional information concerning the future direction of this study.

# # #

AN ECOLOGICAL STUDY OF THE LEECHES OF ISLE ROYALE NATIONAL PARK, MICHIGAN  
ISRO-N-1

INVESTIGATOR: Martin W. Grosnick  
Northern Michigan University

SUMMARY OF PROGRESS: Progress in writing the thesis has been slowed by teaching and course work, as well as employment. Present plans call for its completion in April (1974) and graduation in May (1974).

DEMOGRAPHIC PARAMETERS OF ISLE ROYALE SMALL MAMMALS  
ISRO-N-1

INVESTIGATOR: Wendel J. Johnson  
University of Wisconsin Center, Marinette

SUMMARY OF No active field work was done during 1973. Research manuscripts are  
PROGRESS: being prepared for publication. This work has proceeded at a slow pace  
due to teaching demands.

During January 1974, a proposal will be submitted to the National Park Service for a  
limited amount of field research in 1974.

# # #

ECOLOGY OF THE ISLE ROYALE MOOSE RANGE

INVESTIGATOR: L. W. Krefting  
University of Minnesota

SUMMARY OF Plans are to publish this research in the Technical Bulletin Series or  
PROGRESS: the Monograph Series of the *Journal of Wildlife Management*.

# # #

ISLE ROYALE-LAKE SUPERIOR AS A FOREST WILDLIFE ECOSYSTEM  
ISRO-N-19

INVESTIGATORS: H. L. Hansen, V. Kurmis) University of Minnesota  
L. W. Krefting ) U.S. Bureau of Sport Fisheries and Wildlife

SUMMARY OF This research was published in October 1973. The title was The Forest  
PROGRESS: of Isle Royale in relation to fire history and wildlife. Tech. Bull. 294,  
Agriculture Experiment Station, University of Minnesota.

# # #

GEOLOGICAL SURVEY OF ISLE ROYALE  
ISEO-N-3

INVESTIGATOR: N. King Huber  
U.S. Geological Survey

SUMMARY OF The project has been completed.  
PROGRESS:

OBJECTIVES: To prepare: (1) a modern geologic map of Isle Royale; (2) technical reports on various aspects of the geology; and (3) a nontechnical bulletin for the interested visitor on the park's geology and geologic history.

A paucity of detailed geologic information about the island previously made it difficult to develop an interpretive program on the geology of the park. Results of this study should assist the National Park Service in presenting the geology of Isle Royale in a more meaningful way.

Publications:

Pink copper-bearing prehnite from Isle Royale National Park, Michigan, by N. King Huber: U.S. Geological Survey Prof. Paper 650-D, p. D63-D68, 1969.

Pink copper-bearing prehnite from Isle Royale National Park, Michigan, by N. King Huber: Earth Science, v. 24, no. 1, p. 9-14, 1971. (Somewhat condensed and popularized version of previous publication).

The Keweenawan geology of Isle Royale, Michigan, by N. King Huber: U.S. Geological Survey Open-file report, 9 p. 1971.

Glacial and postglacial geologic history of Isle Royale National Park, Michigan, by N. King Huber: U.S. Geological Survey Prof. Paper 754-A, 15 p. 1973.

The Copper Harbor Conglomerate (middle Keweenawan) on Isle Royale, Michigan, and its regional implications, by Roger G. Wolff and N. King Huber: U.S. Geological Survey Prof. Paper 754-B, 15 p. 1973.

The Portage Lake Volcanics (middle Keweenawan) on Isle Royale, Michigan, by N. King Huber: U.S. Geological Survey Prof. Paper 754-C, in press.

Geologic map of Isle Royale National Park, by N. King Huber: U.S. Geological Survey Misc. Geologic Investigations Map I-796, scale 1:62,500, in press.

The geologic story of Isle Royale National Park, by N. King Huber: U.S. Geological Survey Bull. 1309, in press. (This is a nontechnical publication designed for the interested park visitor.)

# # #

ECOLOGICAL WILDLIFE STUDY  
ISRO-N-1

INVESTIGATORS: Durward L. Allen) Purdue University  
Rolf O. Peterson)

SUMMARY OF PROGRESS: The winter of 1973 was characterized by unusually high temperatures and average, or below average, snow depths (16-28 inches). The island's wolf population numbered 24 and consisted of two packs, one duo and one loner. The former lead male and female of the West pack (8 wolves), both at least 6.5 years old, died between September 1972 and January 1973. This pack had new leadership in 1973 and had undergone at least 50% turnover since last year. Leadership in the East pack remained the same, and the pack increased to 13 wolves by the addition of a second consecutive litter of pups. Their fear of the study craft indicated recent harassment from strange aircraft. Moose mortality due to wolf predation was relatively unaffected by snow conditions in 1973, with carcass utilization, total kill, and calf kill (26% of total) essentially normal. Predation on "prime-age" moose continued to be high (56% of the adults killed were less than 5 years of age).

In over 1100 miles of summer hiking, remains of 123 moose were examined. A total of 44 wolf-killed moose from the winter of 1973 have now been collected. Composition counts of the moose herd were made during summer travels and during an aerial count in October. Calf production was at a 4-year high (37% of the cows observed in the aerial sample had calves), probably due to the relatively easy winter. The twinning rate, however, remained low. Wolf usage of park trails (as measured by scat incidence) after visitation began dropped 94% from fall and spring levels. Extensive use of the trails by wolves did not

resume until October. A collection of 540 wolf scats indicated an occurrence of 50% for beaver remains, a significant change from 10 years ago, and indicated extensive use of the high beaver population by wolves. Howling, examination of fresh sign, and occasional observation were techniques used in summer wolf study. The presence of pups in both packs was confirmed, with seven pups present in the East pack and an unknown number in the West pack.

# # #

INVESTIGATION OF PLANT SUCCESSION FOLLOWING FIRE  
ISRO-N-2

INVESTIGATORS: Park Staff  
National Park Service

SUMMARY OF PROGRESS: This project was conceived to observe plant succession following fire. It is thought that photographs taken on a 10 year basis would be sufficient to observe reasonably this succession. The next set of photos will be obtained in 1974.

KATMAI NATIONAL MONUMENT

PETROLOGIC AND GEOPHYSICAL INVESTIGATIONS OF KATMAI VOLCANOES  
KATM-N-4,6

INVESTIGATOR: Robert B. Forbes  
University of Alaska

SUMMARY OF PROGRESS: Work within the monument involved the following:  
Equipment checks and restoration of KATM station.  
Stratigraphic work at terminus of trident ash flow.  
(Dr. Vorkow, Sr. Volconologist, Soviet Research assisted Dr. Kierle, U of A, in this work)  
Work done in the monument was of a follow-up or maintenance nature.  
Progress reports will be forthcoming.

MARINE MAMMAL SURVEY  
KATM-N-12

INVESTIGATOR: National Park Service

SUMMARY OF PROGRESS: Three flights of Katmai coast were made and data on sea mammals were recorded. Reports were made on these flights. A consolidated report on the data collected to date is being compiled.

# # #

HUMAN IMPACT ON NATURAL VEGETATION  
KARM-N-20

INVESTIGATOR: John G. Dennis  
National Park Service

SUMMARY OF PROGRESS: Initial work has been aimed at describing soil physical conditions in areas of present or proposed development. Monument personnel have contributed greatly toward obtaining an annual soil temperature curve for the Brooks Camp area. Instantaneous, summer season soil temperature profiles have been made at Brooks Camp and vicinity, the area around the Bay of Islands, on the Naknek Peninsula, at the west end of Naknek Lake, and near Devil's Cove of Kulak Bay. Preliminary and very tentative conclusions of these spot investigations suggest that much or all of the north and west shoreline of Naknek Lake contains colder soils than the soil at the Brooks Camp weather station, and that these differences, if real, do not relate directly to vegetational patterns. It seems reasonable to hypothesize that such differences, if they prove to be real, relate more to differences in soil parent material than in vegetation.

SIGNIFICANT FINDINGS: If the colder soils of the north shoreline contain permafrost or at least seasonal frost late into the summer, as tentatively suggested by the spot measurements and by the vegetation of the western part of the area, then development and use of the area may require additional preliminary soil studies to identify specific locations of extremely high or low susceptibility to disturbance.

RECOMMENDATIONS: The work should proceed as planned. Support level ideally should be increased to permit more intensive field study.

# # #

VEGETATION MAP OF KATMAI NATIONAL MONUMENT  
KATM-N-18

INVESTIGATOR: John G. Dennis  
National Park Service

SUMMARY OF PROGRESS: Additional air photo coverage has been obtained for most of the proposed additions. Three weeks in late June and early and mid-July were used for field checks in areas around the Bay of Islands, Naknek Peninsula, Devil's Cove of Kukak Bay, Brooks Camp, and the Valley of Ten Thousand Smokes.

Vascular plant voucher collections were made of each site. The most notable addition to the monument's known flora was aspen (*Populus tremuloides*), which addition represents a range extension of perhaps 30-40 miles. The aspen trees constitute a small stand in an old white spruce forest on a small terrace near the Bay of Islands. The oldest aspen is at least 75 years old, the oldest white spruce appears to be greater than 300 years old.

Identifications of the 194 plant specimens collected have not been completed. Tentative determinations to date suggest that at least four other species, in addition to aspen, can be added to Cahalane's flora of the monument. Datmai represents the edge of range for two of these species, one of which is an orchid (*Dactylorhiza aristata*), the other is devil's club (*Echinopanax horridum*). The other species to be added to Cahalane's list are the alder parasite (*Boschniakia rossica*) and the sundew (*Drosera rotundifolia*).

Plant community studies were limited to surveys that included either simple presence lists, semiquantitative abundance estimations, or cover-height determinations in selected quadrats. Communities surveyed included white spruce forest, balsam poplar forest, the aforementioned aspen stand, birch subforest, alder shrubland, bluejoint grassland, dry tundra, dwarf shrub tundra, wet tundra, and grass-sedge marsh.

Invasion of vascular plants into the Valley of Ten Thousand Smokes appears to occur primarily as a downslope progression from remnant patches of vegetation that occur on ridge slopes. In addition, a very limited amount of vascular plants establishment is occurring in moist, lee areas on the valley floor. Finally, a very few isolated, eroded clumps of vascular plant species occur in widely scattered places. The appearance of these clumps and the apparently elevated nature of many of the old fumarole openings suggest that wind and water erosion may continually be reducing the elevation of the valley floor.

Significant findings to date are the floristic additions mentioned above. The aspen stand requires additional investigation to determine whether its significance is great enough to warrant special recognition or protective status.

The work should proceed as planned. Support level ideally should be increased to permit more rapid progress toward completion of the project.

## LAKE MEAD NATIONAL RECREATION AREA

### WATER QUALITY STUDIES OF LAS VEGAS, LAKE MEAD

INVESTIGATOR: James Deacon  
University of Nevada

SUMMARY OF PROGRESS: A continuing study of the water quality and algae growth at various depths and stations in Las Vegas Bay.

## ARCHEOLOGY OF CONSTRUCTION SITES AT LAKE MEAD

INVESTIGATOR: Richard Brooks  
University of Nevada

SUMMARY OF PROGRESS: A continuing series of surveys of proposed construction sites to comply with requirements of Environmental Impact Statements.

# # #

## AIR POLLUTION MONITORING

INVESTIGATOR: Roger Steele  
Desert Research Institute

SUMMARY OF PROGRESS: A series of atmospheric monitoring stations in the lower Colorado River Valley intended to evaluate the effects of the Mohave Generating Plant upon the atmosphere of the area.

# # #

## UNGULATE DIETS IN THE LOWER GRAND CANYON

INVESTIGATORS: R. M. Hansen Paul S. Martin  
Colorado State University University of Arizona

SUMMARY OF PROGRESS: Analysis of the diets of ungulates by identification of undigested fragments in the dung.  
Published in *J. Range Manage.* 26(5) September, 1973.

# # #

## FISHERIES INVESTIGATIONS IN LAKE MEAD

INVESTIGATOR: Bureau of Reclamation

SUMMARY OF PROGRESS: Investigations into the reproductive success of largemouth black bass in Lake Mead.



SIGNIFICANT FINDINGS: Preliminary studies suggest a replacement origin for most of the flint.

RECOMMENDATIONS: I recommend that the course of investigation as outlined in my thesis proposal proceed as planned. In order to complete a geographically representative study, samples are needed from the vicinity of Big Canyon, Devils Canyon, and Evans Canyon. These samples will be collected during spring 1974 if time and funds permit.

# # #

ASSESSMENT OF ARCHEOLOGICAL RESOURCES AT LAKE MEREDITH  
LAME-N-2621

INVESTIGATORS: C. Britt Bousman)  
S. Alan Skinner ) Southern Methodist University

SUMMARY OF PROGRESS: Report is being reviewed by NPS for approval.

RECOMMENDATIONS: Recommendations for development of archaeological resources, plentiful in this area, are made in the report. They include a comprehensive site survey, an excavation program, and development of a few sites for public display.

# # #

RESEARCH ON WALLEYE PERCH

INVESTIGATORS: Joseph E. Kraai)  
John Prentice ) Texas Parks and Wildlife Department

SUMMARY OF PROGRESS: All field collections were completed. Limited field-collected data was analyzed to determine food habits, reproductive habits, age and growth, seasonal distribution and movements, and the presence of parasites.

Because of a lack of manpower during this segment, the schedule completion of this research could not be met. This resulted in a 1-year continuance of the walleye perch study to further analyze data and prepare a final report.

## LASSEN VOLCANIC NATIONAL PARK

### A VEGETATION STUDY OF THE SKI AREA--LASSEN VOLCANIC NATIONAL PARK

INVESTIGATOR: Ecolabs Associates  
Davis, California

SUMMARY OF PROGRESS: The investigator prepared a vegetation map at scale 1 inch = 300 ft, breaking out eight plant communities in the approximately 600-acre area. A narrative accompanies the map.

The purpose of the study was to make available baseline information for an environmental assessment of planning alternatives. Basic methodology included field observation and aerial photo interpretation, with delineation of community boundaries on a 40 x 40 inch mylar sheet. The description of flora includes discussions of: species diversity, rare or endemic species, soil disturbance, successional patterns.

Three new species were reported, previously undiscovered in the park.

# # #

### AN ARCHEOLOGICAL SURVEY OF LASSEN VOLCANIC NATIONAL PARK

INVESTIGATOR: Alfred E. Journey  
California State University, Sacramento

SUMMARY OF PROGRESS: Current research by this investigator is completed. A copy of the report of the findings will be forwarded to the park when finished. The more significant aspects of this work are that there are more archeological sites in the park than previously thought and that an archeological report done in 1962 is suspect.

The work done by this investigator was simply a survey; no test excavations were done. However, further surveying and excavations would probably answer some questions regarding the ways and tribal boundaries of the prehistoric populations that used the park.

In order to ensure quality work in the future, good financial and moral support would be advisable. My own work was hampered in 1972 due to a lack of such support. The cooperative stance that Mr. Vanie and Mr. Murphy accorded me in 1973 is both wise and commendable. I would hope that such support is continued for future archeological investigators.

## LAVA BEDS NATIONAL MONUMENT

### ECOLOGICAL WILDLIFE RANGE STUDIES--DEER LABE-N-009a

INVESTIGATOR: James A. Blaisdell

SUMMARY OF Utilization of bitterbrush during the winter of 1972-73 totaled 9.8%.  
PROGRESS: down slightly from 1971-72. Pellet counts indicated a winter population  
of 1700 deer compared to 1500 in 1971-72. The range has not been  
adversely affected by this slight increase in deer numbers. The California Department  
of Fish and Game has been notified of annual study results.

# # #

### BIGHORN REESTABLISHMENT STUDIES LABE-N-012a

INVESTIGATOR: James A. Blaisdell

SUMMARY OF Records have been kept of the reproduction and lamb survival for the  
PROGRESS: past 2 years. During this period, the 8 ewes have produced 12 lambs.  
Three lambs have been lost, one adult ewe, and one adult ram. Total  
population is presently 17. Water sources have been tended and breeding and lambing  
seasons determined. Predation appears to be normal and not unreasonably decimating.  
Complete data may be found in annual report to Interagency Bighorn Committee.

OBJECTIVES: With the completion of LABE-N-12 (Reintroduction of Bighorn), extended  
and more intensive studies of the resultant bighorn transplant are  
necessary. Success of the reestablishment attempt will depend upon many factors, all of  
which are included in the research. These are:

1. Loss of bighorn through natural or unnatural causes.
2. Reproduction.
3. Survival of lambs.
4. Range use, trends, and carrying capacity, according to population increases.
5. Diseases, parasites, predation, poaching.
6. Water consumption and needs for added supply.
7. Competition with other species, including man.
8. Food habits and mineral requirements.
9. Study social behavior of bighorn sheep as it affects herd migrations and selection  
of new habitat.

METHODS: Observations, both by this investigator and Lava Beds personnel, have  
been instrumental in supplying data and in determining activities of  
the herd. Regular inspection of the 1100-acre enclosure and its three water devices has  
held to a minimum any maintenance needed.

RESULTS AND As was the prognosis last year, all eight ewes lambed this past May and,  
DISCUSSION: for a while, we had a total of 20 bighorn in the pen.  
On 8 July 1973, one of the original ewes was found quite crippled in the  
left hip and she moved on three legs. No wound was evident so we assume an injury  
occurred. On 16 July, the ewe was found dead and mostly consumed by coyotes. Sometime  
between 3-7 September, a lamb was lost and no trace was ever found. We do not know if  
it was the orphaned lamb.

On 1 October, a lamb was observed with a crippled left shoulder. No wound was evident. Later observations indicated almost complete recovery.

On 20 October, one or more trigger-happy persons shot and killed the younger of the two adult rams and apparently injured the older one for he died several weeks later on 24 November. The older ram was not observed with the ewes during the rut, and unless the yearling ram (one of last year's two lambs) accomplished the breeding, none was done. An emergency capture and release program on 8-9 December netted a new 2.5-year-old California bighorn ram from the Shelton National Antelope Refuge in Nevada. Involved in the program were the Bureau of Sport Fisheries and Wildlife, Nevada Department of Fish and Game, California Department of Fish and Game, and the National Park Service (Klamath Falls Group, Lava Beds). We are hoping that the ewes will breed during a later oestrus provided they did not breed in November.

Other data of importance: It has been decided that since the deer numbers in the pen fluctuate between 3 and 30, and do not appear to be in conflict, no management procedures need be initiated in controlling their numbers or their access to the pen (over the fence).

The blue tongue break-out in deer near Keno, Oregon, does not appear to be a threat to the bighorn at the present time. Close watch will be kept, however.

Public relations continued via speeches, radio, and TV. Publicity has been good, both via the local newspaper and our own releases. Programs presented by this investigator numbered over a dozen.

CONCLUSIONS: Even with the setbacks (half natural and half man-caused), the program is progressing well. In 2 years we have moved from 10 animals to 17, and production in the near future should proceed at about the same or greater rate. Reward money from private citizens and concerned groups has risen to over \$3000 for the capture and conviction of the ram-killers; it is hoped this will eliminate future shootings.

PLANS FOR 1974: Continue studies as they have been conducted the past 2 years.

Publications:

Ovis-on-the-Rocks, with a little help from my friends. Desert Bighorn Council  
Trans. 1973.

# # #

FIRE ECOLOGY - ALL PLANT COMMUNITIES  
LABE-N-0016.17,18

INVESTIGATOR: James A. Blaisdell

SUMMARY OF PROGRESS: Eight ground cover transects have been placed and read in the two wild-fire areas of 1973. Also checked were two older transects already in place.

RESOURCES OF THE PETROGLYPH SECTION AND PENINSULA  
LABE-N-0022

INVESTIGATORS: Stephen Murrill)  
Steve Hall ) University of California at Davis  
Kathlin Hajas )

SUMMARY OF Work begun by students Alice Owens, John Morris, Ken Leal, Dan McNeill,  
PROGRESS: and Ken Ealy for class work, University of California--Davis summer  
course, Winema Hunt Club. Countinued by Murrill, Hall, Hajas, under  
contract and general supervision of James Blaisdell. Full ecological report due end of  
1973.

# # #

NATURAL HISTORY HANDBOOK  
LABE-N-0011

INVESTIGATOR: John Krambrink  
National Park Service

SUMMARY OF Initial manuscript complete. We have been informed it is now ready for  
PROGRESS: the printer.

LONG ISLAND, NEW YORK

SURVEY OF FISH-EATING BIRD COLONIES ON LONG ISLAND, N.Y.

INVESTIGATOR: P. A. Buckley

OBJECTIVES AND METHODS: To survey by whatever means available all Long Island colonies of fish-  
eating birds, including waders, gulls, terns, and skimmers--very many  
of which are concentrated in GATE and FIIS--for accurate species, number,  
and colony site characteristics data so that their numbers may be monitored in the  
future for pesticide effects or other population changes we might otherwise be unaware of.  
Despite the concentration of observers and the existence of an excellent book on local  
ornithology, little systematic work has been done censusing local colonies of fish-  
eating birds, which contrasts markedly with data from neighboring New England where the  
Massachusetts Audubon Society has been carrying on a vigorous program in recent years.  
Hopefully, the Long Island survey will enable comparison with data from New England and  
will form a link in a chain of annual such censuses embracing the whole U.S. coast. Most  
of the Pacific Coast is already covered annually, and the Gulf Coast is rapidly reaching  
that goal.

RESULTS: The results of the 1973 survey were published in my column in *American Birds*, although these figures did not indicate breeding success, merely numbers of pairs estimated/counted present. They are summarized in Table 1, with the figure in brackets following the Long Island total indicating approximately how many are on NPS-administered lands or (alas, more frequently) while not breeding on NPS-lands spend sufficient feeding time there to be considered important to NPS interests.

Table 1.

Species	# breeding pairs	# NPS-related breeding pairs
Little Blue Heron	27	20
Cattle Egret	4	0 (but see discussion)
Great Egret	122	0
Snowy Egret	500	80
Louisiana Heron	13	6
Black-crowned Night Heron	725	220
Glossy Ibis	675	130
Herring Gull	5800	2750
Great Black-backed Gull	210	80
Common Tern	9200	2500
Roseate Tern	1700	50
Least Tern	540	125
Black Skimmer	520	230
	<u>20,036</u>	<u>6191 (31%)</u>

DISCUSSION: Despite no coverage in the very large heronry in the vast, largely unspoiled Lawrence Marsh north of Long Beach--where probably all species of breeding Long Island herons occur, including the 25+ pairs of Cattle Egrets that fed all summer long on runways at JFK Airport and at Jamaica Bay Wildlife Sanctuary (GATE)--these are surprising heron totals. (Noncolonial or small-colony species such as the bitterns, Green, and Yellow-crowned Night Herons are not included). The Glossy Ibis figure was especially high, all the more when one considers that it is probably underestimated by a factor of 2, as were their preferred colony associates, Black-crowned Night Herons. These species' colonies are particularly difficult to detect from the air and are frequently overlooked on the ground unless the adults are accidentally flushed. Two new colonies were discovered from the air, one containing all Long Island breeding herons and ibises (some 500 pairs) and the second lacking only two species (425 pairs).

Terns seemed to be doing better than subjective impressions had indicated, although, as mentioned, these are not breeding success figures, merely pairs of attending adults. Alarming were the very low figures for Least Tern and Black Skimmer; one 600-pair Least Tern colony from 1972 failed to materialize at all this year. Gulls are doing distressingly well and are still apparently expanding and generating new colonies.

Of particular concern was the percentage of colonies sited on artificially constructed drudge-spoil islands, at various stages of succession: herons, 700 pairs out of 2100 (33%); gulls, 2500 pairs out of 3800 (43%); and terns, 4000 pairs out of 12,000 (33%). While the dependency of these birds on these artificial and almost always unprotected sites does not approach that of CAHA (95%), these figures still have several important implications: (1) Is the population of these birds limited by available habitat? (2) Have they been forced off natural situations by human pressure? (3) Can management of these spoil banks increase the birds; numbers? (4) What is the legal status of these areas in terms of protection from public assault or spoil dumping during breeding seasons? (5) How can the Service help?

Finally, the figures in Table 1 emphasize the need for an ecosystem approach to the various units in the Service on Long Island. While many of these birds do not nest in our parks, they are in many ways dependent on them for sustenance and population health. Biologically, we extend far beyond our statutory boundaries.

PLANS FOR 1974: This survey generated a great deal of local interest, and it seems likely we will be able to call upon a great cadre of local, competent volunteers to repeat it, hopefully also extending it to obtaining breeding success data as well. Effort will also be made to integrate it fully into the existing net of similar studies elsewhere in North America.

Publications:

Buckley, P. A., and T. H. Davis, Jr. 1973. The Hudson-St. Lawrence Region [summer season 1973]. *American Birds*, 27:845-852.

## MAMMOTH CAVE NATIONAL PARK

### HYDROLOGY OF MAMMOTH CAVE MACA - 1 MACA-N-1

INVESTIGATOR: U.S. Geological Survey

SUMMARY OF PROGRESS: The project remained in a monitoring status throughout 1973. Measurements of flow, water level, and water quality were maintained at observation points which were selected so as to monitor most present and potential water supplies available to the park. The recording bubble gauges on Green River and Beaver Dam Creek and water-level recorders on four observation wells were continued in operation to monitor seasonal and long-term changes in the available supply. Discharge measurements were made periodically on Wet Prong Buffalo Creek, Beaver Dam Creek, Bylew Creek, and Dog Creek, and on Echo River and Styx River outlets, especially during periods of low flow. Sampling for chemical-quality analysis was continued periodically especially at low flow at 10 sites on streams, springs, and wells. The samples were analyzed at the Survey's regional laboratory at Columbus, Ohio, and the results forwarded to the National Park Service. Sampling of all developed water sources was done in October.

Stream discharges and ground-water levels were above normal at the end of the year. No marked change in chemical quality of streams and ground water were noted.

The monitoring program should be continued to provide data on changes that might occur in the amount and chemical quality of the water supply potential at Mammoth Cave National Park. Expansion of the monitoring program should be considered to include monitoring of possible water pollution in the cave complex and in present and potential sources of supply. When the recommendations of the Master Plan Team are made available, it may be desirable to expand the project to provide additional data on potential water supplies and on the flow and movement of subsurface water through the park.

DEER POPULATION STUDY  
MACA-N-2

INVESTIGATOR: Pete Troublefield  
Kentucky Department of Fish and Wildlife Resources

SUMMARY OF PROGRESS: Herd Reduction Program: The 15th trapping season ended 31 March 1973. At that time a total of 4120 deer had been successfully transplanted throughout Kentucky. The total catch during this season was 105. Of these, 13 mortalities occurred, 11 were given to the bureau project, and the remainder transplanted. The 16th season was instituted in August 1973. As of 30 November, 153 deer had been taken from up to 80 active traps. There were 10 mortalities and 143 transplants.

Browse Studies: The Aldous Method is used to estimate the availability and use of browse on the park. This survey has been conducted for the past 18 years. Two browse indices (BI) are obtained from each survey; one index for "all browse plant genera" and one "preferred plant genera". A BI of 100 is considered the maximum degree of browsing a plant can withstand without retarding plant growth and reproduction. Mammoth Cave exhibited an overall BI of 118, or -3 from the 1972 survey. The preferred index was 234, down 6 from 1972. These changes are insignificant when the area's indices continue to be so high. Of the 45 plant groups utilized, 32 were overbrowsed.

# # #

ECOLOGY AND LIFE HISTORIES OF CAVE BEETLES  
MACA-N-4

INVESTIGATOR: Thomas C. Barr, Jr.  
University of Kentucky

SUMMARY OF PROGRESS: All information collected on this study was turned over to Mr. T. R. McKinney, who will report the status independently under RSP 35. Although a limited amount of study will probably be conducted on the two very rare *Pseudanophthalmus* spp. in the park, it will be transitory in nature because they occur seasonally and in very small numbers. MACA 4, in accordance with communication with Leonard McKenzie, should be considered inactive at the present time.

# # #

MICRO- AND MESOFAUNA OF AQUATIC HABITATS IN MAMMOTH CAVE  
MACA-N-6

INVESTIGATOR: Thomas C. Barr, Jr.  
Un University of Kentucky

SUMMARY OF PROGRESS: This project has been incorporated into the NPS-funded study on sewage pollution and its ecological effects on the cave fauna. Efforts have been directed primarily toward:  
a) establishing the generality of the protozoan community as characterized by

Gittleson and Hoover;

- b) obtaining expert determinations on the minute, thread-like oligochaetes in the silts along the cave streams; and
- c) further characterizing the minute aquatic fauna encountered in the cave pools and streams, especially in bottom silts.

MACA 6 should no longer have a separate project number in my judgment; this was communicated to Leonard McKenzie earlier this year.

# # #

A STUDY OF THE HYDROLOGY AND GEOMORPHOLOGY OF CEDAR SINK,  
MAMMOTH CAVE NATIONAL PARK  
MACA-N-8

INVESTIGATOR: Robert J. Hosley  
Natural Sciences Resource Studies Group

SUMMARY OF PROGRESS: Limitations on time and personnel due to surveying and leveling work in Mammoth and Ganter caves<sup>1</sup>, not related to RSP MACA-N-8, resulted in little work being accomplished in the Cedar Sink area. However, some reconnaissance mapping continued in a northeast-trending water-passage in Smith Valley Cave. Only a small portion of this difficult passage remains, and final cartography of this cave is expected to commence once the remaining data are acquired. I recommend that this project be terminated when the remaining reconnaissance mapping has been completed. Office studies, although not field work, will continue until the objectives of the project have been reached.

<sup>1</sup>For RSP MACA-N-32.

# # #

AQUATIC CAVE ECOLOGY  
MACA-N-15

INVESTIGATOR: Thomas L. Paulson  
University of Illinois at Chicago Circle

SUMMARY OF PROGRESS: Very little new data to add because of (a) concentration on MACA-N-14 (see CRF Annual report); (b) training of new junior biologists in the techniques of biological survey and correct identification of organisms.

Dr. "Beep" (H. H. III) Hobbs helped with an aquatic survey of Eyeless Fish Trail in the Austin entrance area of F.R. (This is part of long-time followup, looking for trends in fish and crayfish populations--the format and earlier results are well described in CRF Annual Report area 1964-68). No obvious change in 10 years.

Rick Olson (CRF-JV) was trained on several trips and made his first independent biosurvey in a portion of the "Elephant Trunk" Mammoth Cave. The aim of this work is to find more areas where the *Typhlichthys* and *Amblyopsis* species of blindfish overlap in range within the cave.

The first spinefish (*Choligostes*) occurrence in River Styx in the last 5 years was noted this fall. The last occurrence was in 1968.

REPRODUCTION REGULATION OF WHITE-TAILED DEER IN MAMMOTH CAVE NATIONAL PARK  
MACA-N-21

INVESTIGATORS: George H. Matschke)  
Robert D. Roughton) U.S. Fish & Wildlife Service

SUMMARY OF PROGRESS: Melengestrol acetate (MGA) was fed ad libitum on either a daily, alternate, or tridaily schedule at 0.6 g/ton during the 1972-73 breeding season. Eight of 9 and 3 of 9 yearlings or older females on the 0.6 g/ton tridaily and alternate schedule conceived, respectively, and for the 0.3 g/ton on the tri, alternate, and daily feeding schedule 5 of 7, 4 of 8, and 6 of 14 females conceived, respectively. Eight of 9 control females conceived. Thus these tests indicate that for MGA to be effective as an oral chemosterilant it must be consumed on a daily basis at 0.6 g/ton; therefore, future MGA research at this low level and daily feeding is not warranted.

Two MGA 1971 rectangular silastic implants (5% by concentration) proved effective for 2 consecutive breeding seasons, and the 1972 spherical implants (2 at 5% and 2 at 10% by concentration) were effective this breeding season. The two 1971 implants were excised to be assayed. Implant retention is a problem as the loss rate has been 61% (14 out of 23) with a 24th animal being an unknown, but a probable loss.

A nonchemical approach, i.e., an intravaginal polyethylene "penis blocker" device inserted into the vagina of four females, proved to be noneffective as copulation and ejaculation were not impaired enough to prevent conception in all does. Future research with this device is not warranted.

The search continues for a chemosterilant capable of being effective in a single oral dose, or in a feeding regime that would require only a couple of feedings per breeding season. Four tests to meet this objective are currently underway:

1. Diethylstilbestrol (DES) is a compound with estrogen-like properties and is capable of being both an antioviulatory or abortifacient. Like most estrogens or estrogen-like compounds, oral acceptance is a problem. Abbott Laboratories has supplied microencapsulated DES and a 3-stage switchback feeding regime at 5 dose levels has been completed; no significant difference occurred between the three highest dose levels of 500, 750, and 1000 mg. A stall study using 10 female deer (6 treated, 4 control) and feeding 1000 mg every 17th day is now in progress, and the object is to expel the blastocyst prior to implantation.
2. The three other tests involve MGA and DRC-6246, both progesterones, and in these cases feeding of high levels is done with the objective of storing the excess compound in the fat so that, during the breeding season, the compound is metabolized at a sufficient rate to prevent ovulation.

Females were fed 1 g of MGA for one feeding, and 7 days post-treatment turned in with the males for the breeding season; in the second MGA study the females were fed 50 mg/day for 7 days and likewise 7 days post-treatment placed with the males. DRC-6246, 1 g, will be fed over 30 days during the breeding season.

MGA silastic carriers release tables prepared by the manufacturer indicate that the small size and low concentration implants probably would not last the reproductive life of the female deer and, because of the high loss rate when placed under the skin, it was decided to construct large implants, 1.7 x 11.0 cm cylinder vaginal implants, at 30% concentration for MGA and 20% for DES.

Implant research to date has not established any quantitative data as to an effective dose for this species. Silastic tube-type implants have a zero order release rate, enabling one to establish an effective dose. Commercial tube-type implants with predetermined release rates using DES and DRC 6246 have been inserted in penned deer. A

contract was let with Ohio State University to obtain this type of data with MGA and also efficacy and residue data which would prove useful for registration purposes.

RECOMMENDATIONS: An implant efficacy study should be designed and implemented this next breeding season (1974-75) either on a deer herd within a large enclosure or one that is free-ranging; likewise an oral DES-MGA acceptance field study should be designed provided the fawning data collected this summer warrants it.

# # #

PLANT ECOLOGY OF MAMMOTH CAVE NATIONAL PARK  
MACA-N-23

INVESTIGATORS: M. T. Jackson) Indiana State University  
Adolph Faller)

SUMMARY OF The entire Ph.D. study is completed except for the final draft of the  
PROGRESS: dissertation and passing the final examination. The latter has been  
scheduled for 25 January 1974.

Subsequent to finishing the dissertation it will take several months to prepare a monograph based on the study for publication.

# # #

ARCHEOLOGY OF THE MAMMOTH CAVE AREA  
MACA-N-24

INVESTIGATOR: Patty Jo Watson  
Washington University

SUMMARY OF A detailed account of progress and of significant findings is contained  
PROGRESS: in two publications (Patty Jo Watson et al. The Prehistory of Salts Cave, Kentucky. Illinois State Museum, 1969; and Archeology of the Mammoth Cave Area. Academic Press, due out April, 1974) and in papers published or presented at professional meetings and sent to the Superintendent for his files. Briefly stated, we have been concerned with documenting aboriginal activity in four caves (Salts Cave, Mammoth Cave, See Cave, and Bluff Cave) and in selected surface areas within Mammoth Cave National Park (around Salts Sink, along Green River between Denison's Ferry and Three Sisters' Hollow, near Daniel's cemetery, and at Indian Hill).

For the future, we need to know more about surface archeology in the park, and we also need to expand our paleoenvironmental research by recovery of more pollen and charred macrobotanical remains from Salts Cave Vestibule and from the nearby Green River shell-mounds. I have applied to the National Geographic Society for renewed funds for these purposes.

CHARACTERIZATION OF SUBCLIMAX PLANT COMMUNITIES IN KARST AREAS  
MACA-N-29

INVESTIGATORS: Thomas C. Barr, Jr.)  
Jerry M. Baskin ) University of Kentucky

SUMMARY OF Work has centered on plant community structure and composition of (a)  
PROGRESS: cedar karren, and (b) sinkhole parks.  
The project is essentially complete and ready to be put into form for  
publication. Dr. Baskin wants to make a few additional observations on spring flora in  
the study areas prior to completion.

# # #

THE KARST MORPHOLOGY AND HYDROLOGY OF THE CENTRAL KENTUCKY KARST  
AT MAMMOTH CAVE  
MACA-N-32

INVESTIGATOR: Franz-Dieter Miotke  
University of Hannover, West Germany

SUMMARY OF Miotke/Palmer: Genetic relationship between caves and landforms in the  
PROGRESS: Mammoth Cave National Park.  
Miotke/Papenberg: Geomorphology and hydrology of the Sinkhole Plain...  
in Caves and Karst, 14, 6, 1972.

Miotke, Derk Zentral-Kentucky-Karst bei Mammoth Cave. 610 p. Habilitationsschrift,  
in press (202 Photographs, 125 Figures, Maps, etc.)

Laboratory work on sediment examples (cave sediments, surface sediments) in progress.  
Date of completion of this research is uncertain.

# # #

NICHE SEPARATION IN THREE SPECIES OF CAVE BEETLE (COLEOPTERA:CARABIDAE)  
MACA-N-35

INVESTIGATOR: Thomas R. McKinney  
University of Kentucky

SUMMARY OF In preference experiments run in Great Onyx Cave, differences were found  
PROGRESS: among the three species in their choice for debris, roughened clay  
substrate, and gravel substrate. No differences were found in the  
beetles' choice for substrates with various moisture contents.

The relative abundance of the beetles in their natural habitat reflects the amount  
and age of litter in the habitat. Because of these litter differences, there are  
differences in the microarthropod and oligochaet fauna in the caves where beetle abundance  
differs. The beetles apparently utilize slightly different food items (although each

beetle will eat almost anything, differences in preference exist) and are thus directly affected by litter conditions.

In accordance with the agreement made with Mr. Leonard McKenzie at the start of this project, a copy of my Ph.D. dissertation will be provided to the park when it is completed.

# # #

THE ECOLOGY OF THE *NEAPHAENOPS*-*HADENOECUS* PREDATOR-PREY SYSTEM  
MACA-N-36

INVESTIGATOR: Russell Norton  
Yale University

SUMMARY OF (A) *Neaphaenops*: (1) shows marked seasonality in : copulation;  
PROGRESS: appearance of larvae, pupae, and adults; sex ratio; (2) feeds chiefly  
on the eggs of *Hadenoecus*, but also takes the early instar nymphs, and  
is a generalized, opportunistic predator; (3) digs more deep holes where a *Hadenoecus*  
egg has been discovered than at an equivalent site where the egg was not found; (4)  
fecundity between caves is correlated with the associated *Hadenoecus* fecundities (January  
1973,  $P = 0.95+$ , additional material to be processed); and (5) is probably an annual  
species.

(B) *Hadenoecus*: (1) shows marked seasonality in oviposition, hatching, and presence  
in interior cave areas; (2) females in MCNP probably have eight instars after hatching;  
(3) the first four instars do not leave the cave, cannot be externally sexed, and are  
clearly separated by hind femur length: approximately 3, 5, 6, and 7 mm, respectively;  
(4) the last four instars can feed outside, can be externally sexed, and may not be  
clearly separated in size; (5) eggs usually hatch in 3 months, but may take over twice  
as long; (6) first instar nymphs do not feed, and molt in 5 weeks; (7) adults live up  
to 1 year in the wild; and (8) is probably a biannual species.

# # #

GEOLOGY AND GEOMORPHOLOGY OF FLOYD COLLINS' CRYSTAL CAVE  
MACA-N-37

INVESTIGATOR: Arthur N. Palmer  
State University of New York, Oneonta

SUMMARY OF Field work in Crystal Cave has been completed (as of 2 August 1973):  
PROGRESS: hand-leveling of all major passages; tying in geologic contacts;  
description and mapping of stratigraphic units; collecting of bedrock  
and sediment samples (permit: January 1973); surface mapping of geomorphic features over  
cave; minor investigations of soil and subsoil bedrock character using portable seismic  
unit; photography of rock units and major cave features.

Analysis of mapping data is in progress. A very strong concordance has been found  
between cave passages and stratigraphic units, with exceptions just beneath the sandstone  
cap-rock and in the lowest levels of the cave. Passages tend to be oriented directly  
down the steepest available component of the local dip, although many show an abrupt  
change of trend in their lower reaches in the direction of the strike. Each major  
bedding-plane parting or contact between stratigraphic units is independent in its

structural character (variations in dip and strike) owing to variations in thickness. Mean dip on the major contacts is 60 ft/mile in the direction N 24W., but with many minor flexures and diagenetic irregularities superimposed. All units in the cave have been correlated with previously described units elsewhere in the Illinois structural basin. Petrographic analysis of rock units will be initiated soon.

During 1974 the rock units mapped in Crystal Cave will be extrapolated throughout the major passages of the Mammoth Cave system, in an attempt to define the overall genetic relationship between passages and their relation to the geologic setting. Laboratory work and analysis of field data should be completed during 1975.

# # #

ECOLOGICAL EFFECTS OF WATER POLLUTANTS ON THE FAUNA OF MAMMOTH CAVE  
MACA-N-40

INVESTIGATOR: T. C. Barr  
University of Kentucky

SUMMARY OF Major pollutants at present identified in the cave system are from backflow  
PROGRESS: of Green River into Echo River, with relatively high coliform counts (for dilute winter flow) of several hundred/100 ml.

Evidence of fecal pollution has been found in several small streams or trickles which supposedly percolate vertically into the cave system from the overlying Mammoth Cave plateau. A moderately high count (on the order of 75-400 total coliforms per 100 ml) and low chloride characterized such percolating water in September and October. Supposed coliform colonies on M-Endo Broth medium were further investigated and four out of five proved to be *E. coli*, further substantiating supposition of fecal pollution. In November and December the total coliform count dropped very low (0-10/100 ml) in these little streams, but chloride concentration approximately doubled. The same streams also proved to contain high counts of fecal streptococci, which persisted into November at a time when the total coliform count had become extremely low.

A small spring at Houchins Ferry, investigated at the request of the Park Research Geologist, proved to be highly polluted by coliforms and fecal streptococci alike, with total coliform counts ranging from 6750 in late September down to a few hundred (at the mouth of the spring) in late November.

Current studies, which have dealt thus far with intermediate levels of presumed fecal pollution, show no indication of ecological imbalance in the fauna of pools and streams as a result of the pollution.

# # #

THE ECOLOGY AND EVOLUTION OF CAVE INVERTEBRATES, ESPECIALLY BEETLES.  
PRESENT SPECIFIC RESEARCH PROBLEM: POPULATION GENETICS OF  
TROGLOBITIC *PTOMAPHAGUS* BEETLES.  
MACA-N-1

INVESTIGATORS: Stewart B. Peck)  
George Carmody ) Carleton University  
Cameron Laing )

SUMMARY OF PROGRESS: A study of the genetics of some populations of the troglobitic beetle *Ptomaphagus hirtus* is continuing in our laboratory. The technique of electrophoresis is presently being applied to beetles collected from two caves in Mammoth Cave National Park as well as to material obtained from four other areas in Kentucky. An early evaluation indicates the presence of electrophoretic variation both between and within populations. Its significance cannot yet be evaluated. The study is continuing.

## MESA VERDE NATIONAL PARK

### RAPTOR INVENTORY OF MESA VERDE NATIONAL PARK

INVESTIGATORS: Rick Anderson ) Mesa Verde  
Gerry Craig ) Colorado Division of Wildlife  
Phil Dittberner) Denver Service Center

SUMMARY OF PROGRESS: The purpose of this study is to determine the raptor population of Mesa Verde National Park and adjacent areas whose populations may be transient to the park. Species we are most interested in for the study are the Peregrine and Prairie Falcons. Field work will be done in April 1974, and eyries located and ranges defined. The study should be completed in September 1974.

# # #

### PLANT COMMUNITIES OF MESA VERDE NATIONAL PARK

INVESTIGATOR: Phil Dittberner  
Denver Service Center

SUMMARY OF PROGRESS: This study is to describe the major plant communities of Mesa Verde National Park and to make a vegetative map of the park. An existing 1939 vegetation map will be updated and information affecting the vegetation, such as fires, will be included. The field work will be done in April 1974, and the study completed in October 1974.

# # #

### SOIL RECONNAISSANCE OF SELECTED SITES OF MESA VERDE NATIONAL PARK

INVESTIGATORS: Lain Co. Phil Dittberner  
Fort Collins, Colorado Denver Service Center

SUMMARY OF PROGRESS: The purpose of this study is to survey soils of Mesa Verde National Park to locate fragile areas and areas suitable for various developments and uses. The study will cover approximately 7200 acres and determine the associated soil series. The data will be used in helping to direct the Master Plan proposals and determining Environmental Impacts. Field study will be in March-June 1974, and the final report completed in July 1974.

# # #

#### USEFULNESS OF REMOTELY SENSED SATELLITE DATA IN RESOURCE INVENTORIES

INVESTIGATORS: Harry Hitchcock) Purdue University  
Roger Hoffer )  
Paula Krebs ) University of Colorado  
Phil Dittberner) Denver Service Center

SUMMARY OF PROGRESS: The purpose of this study is to determine how useful SKYLAB remotely sensed data is in inventorying the resources of Mesa Verde National Park and some adjacent areas. Preliminary results indicate usefulness for vegetative mapping and possibly inventorying archeological resources. The SKYLAB and similarly obtained data are probably of most benefit on large area studies as a first step in resource inventorying with follow-up field studies and ground-truthing to validate results. As a result of this study, it is hoped the National Park Service can make suggestions in refining the data acquisition system and machine manipulation procedures to make the data more useful and more easily interpreted to natural resource managers and planning efforts.

The initial field study by Harry Hitchcock was completed in March 1974, and the study should be completed in a year.

#### MOUNT MCKINLEY NATIONAL PARK

#### WOLF-CARIBOU RANGE; CARIBOU MIGRATION MOMC-N-10

INVESTIGATOR: NPA - BLM - ADF&G Personnel

SUMMARY OF PROGRESS: Three flights to determine caribou and wolf use areas were made. Wolf use areas were substantially the same as in prior years. Caribou were in considerably lesser numbers. Summer counts of caribou indicate lesser numbers in the park area or the adjacent areas. The same holds true for winter census. Use of government aircraft precluded winter caribou census. Funds precluded charter flights.

The largest count of caribou numbered about 1000 animals.

SHEEP CENSUS  
MOMC-N-13

INVESTIGATOR: NPS Personnel

SUMMARY OF PROGRESS: During the last year the National Park Service did not conduct a sheep survey. However, Gordon Haber and Chalan Harris did fly a sheep survey during June 1973 and came up with a count of 1136 animals.

Sheep numbers, like caribou, are down. Field studies do not reveal winter or predator mortality.

# # #

SOCIOECOLOGICAL DYNAMICS OF WOLVES AND PREY IN A SUBARCTIC BIOSYSTEM

INVESTIGATORS: G. Haber )  
I.McT. Cowan) University of British Columbia

SUMMARY OF PROGRESS: A Ph.D. Thesis is currently in preparation, covering major aspects of the research 1966-74. Project to continue indefinitely, but further major field work will not be undertaken until thesis is completed.

There is no fixed completion date for thesis although hopefully it will be completed in 1974.

# # #

MOOSE RANGE STATION  
MOMC-N-14

INVESTIGATOR: NPS Personnel

SUMMARY OF PROGRESS: No additional range transects have been established nor have existing transects been evaluated. Evaluation of transects and plots (12) is scheduled for next year.

# MT. RAINIER NATIONAL PARK

## FLORISTICS OF PIERCE COUNTY, WASHINGTON

INVESTIGATOR: Irene O. Creso  
University of Puget Sound

SUMMARY OF PROGRESS: This project has a twofold involvement: (1) part of a statewide investigation headed by Dr. James R. Slater, emeritus, Univ. of Puget Sound, Tacoma; and (2) a study designed for ultimate publication as a key for local use. There are two universities, two community colleges, and numerous high schools in need of such a work. Various individuals are interested also.

So far, many specimens have been collected and mounted, many more noted as to exact location.

SIGNIFICANT FINDINGS: A number of species, not before recorded for the county, have been noted or collected. Many ranges extended. Not all of this is confined to MRNP.

RECOMMENDATIONS: Probably will continue as planned.

# # #

## SEISMICITY OF WASHINGTON STATE (MT. RAINIER AREA)

INVESTIGATORS: Stewart W. Smith)  
Stephen Malone ) University of Washington  
Mr. Rasmussen )

SUMMARY OF PROGRESS: Monitor large rock and ice falls on Mt. Rainier. Use data in epicenter determination of Washington State earthquakes. Monitor local seismicity (tectonic) in Mt. Rainier area.

SIGNIFICANT FINDINGS: Rainier is a tectonic-active area. Raock and ice fall activity is related to possible volcanic activity.

RECOMMENDATIONS: We will continue with our studies as in the past.

# # #

## HEAVY SEDIMENTS OF MT. RAINIER NATIONAL PARK

INVESTIGATOR: Conrad M. Tedlund  
University of Puget Sound

SUMMARY OF PROGRESS: I collected stream sediments from two sites in each of six drainage basins of Mt. Rainier. One sample was taken from a site on the slope of the mountain, while the other was collected lower down in the basin, but within the boundary of the park. The sediments were separated according to size,

and then by their magnetic qualities.

In each case, the sediments lower down were more magnetic, finer, and heavier than those farther up. When I ran the sediments through a magnetometer to help determine amounts and types of the different minerals, there were definite variations in the amount of certain minerals on different sides of the mountain. I did not have enough time to run all the samples through the x-ray diffractometer so not everything has been analyzed yet. More work may be done in the future by another UPS student.

# # #

## ECOLOGICAL DISTRIBUTION OF THE TERRESTRIAL SNAILS OF THE CASCADE MOUNTAINS

INVESTIGATOR: Branley A. Branson  
Eastern Kentucky University

SUMMARY OF PROGRESS: During the summer, I was able to make terrestrial snail collections from the following locations in the park: Tipsoo Lake area, Sunrise Junction, Emmons Glacier Trail, White River campground (many unsuccessful stops between Sunrise and White River), Junction of Mather Memorial Parkway and White River Entrance, Deer Creek Crossing (between White River and Ohanapecosh), Silver Falls area of Ohanapecosh River, Grove of the Patriarchs, Box Canyon of the Cowliz, Reflection Lakes, Narada Falls, Sunshine Point, Westside Road (3.2 miles from its junction with Route 706), Westside Road along Puyallup River, Kautz Mud Flow, and Tolmie Peak.

I have not yet prepared the data for publication, but shall send along a reprint of the paper when it is published.

# # #

## ECOLOGY OF SUBALPINE MEADOWS FLORA OF MT. RAINIER NATIONAL PARK

INVESTIGATOR: Jan A. Henderson  
Utah State University

SUMMARY OF PROGRESS: Composition, distribution and succession of subalpine meadows in Mt. Rainier National Park, Ph.D. dissertation submitted to Oregon State University, July 1973, describes and defines the vegetation types and community types in the park and describes their distribution (15-color map included in dissertation) and succession.

In addition, a color map and description of the vegetation and trails of Paradise Park are in preparation and expected to be finished by 1 January 1974. It is expected that it will then be published for sale to the public.

Flora of Mt. Rainier National Park, which is about half completed. It was planned as a revised and updated "Flora" to include much more ecological information than the usual floristic key (such as G. N. Jones' 1938 edition). I will try to finish the field work next summer.

ELK INVENTORY  
MORA-N-7a

INVESTIGATOR: Mt. Rainier National Park Personnel

SUMMARY OF  
PROGRESS: The 12 pellet plot transects were each read and cleared at least once. Several were read a second time in an effort to gauge short-time use of specific areas.

# # #

ELK RANGE CONDITION AND FOOD HABITS  
MORA-N-6a

INVESTIGATOR: Mt. Rainier National Park Personnel

SUMMARY OF  
PROGRESS: The permanent vegetation transects previously established were not read during the past year although several were located for further reference. Since these should be read every 3-4 years to record changes, an effort will be made to do so.

# # #

STUDIES ON THE EFFECTS OF ELK ON THE ECOSYSTEMS WITHIN MT. RAINIER NATIONAL PARK  
MORA-N-4a

INVESTIGATOR: Charles H. Driver  
University of Washington

SUMMARY OF  
PROGRESS: Initial studies were installed to determine the impact of elk use of plant ecosystems in critical areas within the park boundary. These activities consisted of the following: (1) locating areas exhibiting extreme evidence; (2) establishing studies to benchmark and serve as measures of extent and rates of impact on the ecosystems; (3) conducting observations on populations of elk and period of use of the critical study areas; (4) initiating, in cooperation with park personnel, observations on elk movement patterns in relation to the development of management practices to control undesirable elk populations within the park; (5) establishing positive cooperative actions with agencies managing natural resources around the park (U.S. Forest Service National Forest personnel and Washington State Department of Game and Forest Industries) in an effort to develop resources management policies and practices that affect elk populations using the park's range resources; and (6) participating actively in two meetings of the Mt. Rainier Elk Management Committee.

All activities initiated this past field season will be continued for the next 2 years or lesser time until meaningful results are derived that will document impact actions on the ecosystem resulting from actions of elk.

Cooperative efforts with the park's personnel will be expanded by way of use of radio-marked elk tracing to better establish the year-around patterns of elk movement within and around the park.

A cooperative effort will be organized with agencies of the Elk Management Committee to develop data to construct a "life table" of elk herds utilizing the park. Such a "table" will serve as an ecologically sound basis for management of these herds.

# # #

ELK MIGRATION  
MORA-N-3a

INVESTIGATOR: Mt. Rainier National Park Personnel

SUMMARY OF           Forty elk have been trapped, tagged, and released during the past year.  
PROGRESS:           A new method of tagging is being initiated using rope collars with  
                          colored flags attached. These should remain readable for a longer period  
of time than the previously used markers.

Through the 1972-73 season, 133 elk were tagged. Increased observations in back-country have given data on distribution.

Tagging will continue for 3-4 years in support of MORA-N-4a.

NORTH CASCADES NATIONAL PARK

MOUNTAIN STREAM ECOLOGY  
NOCA-N-23

INVESTIGATOR: C. Robert Wasem

OBJECTIVES:       1. To determine drainage areas, mean gradients, longitudinal profiles, lengths, widths, substrates, fish migration barriers, water quality and volume of low, relative aquatic macroinvertebrate abundance, and fish populations and spawning areas, etc., of major streams of the park complex.

2. To identify important sport fish populations and portions of accessible streams whose fish habitat might be enhanced to improve the sport fishery in the Ross Lake and Lake Chelan National Recreation Areas.

METHODS:       Stream gradients, lengths, and drainage areas are determined from 7.5 minute USGS topographic maps. Longitudinal profiles are graphed from topographic maps. Standard field techniques will be used to determine substrate materials, stream velocity, stream discharge, stream width, and chemical and physical properties of each stream at accessible points. Drift nets, hand dip nets, and Surber samplers will be used to sample stream invertebrates. Fish will be captured by electrofishing gear, by hook and line, and by small seines. Fish population studies may be made in some streams by capture-mark-release-recapture techniques. Color and black and white photographs will be taken.

RESULTS AND DISCUSSION: This study is not officially funded to begin until 1 July 1974. However, to date some preliminary stream investigations have been carried out and outlined as follows:

1. Basic water quality has been measured each year in a large number of streams beginning in August 1970. Sixty-five stream water quality samplings were made in 1973, with several streams being checked more than one time or in different locations along the stream course. Basic parameters of water quality include air temperature, water temperature, pH, specific conductance, alkalinity, total hardness, Ca hardness, and turbidity. Discharge, water depths, stream widths, and velocity were also determined in several streams in 1972 and 1973. These streams were Newhalem Creek, Granite Creek, Marble Creek, Company Creek, and the Chilliwack River.
2. Longitudinal gradient profiles have been graphed for 105 complete streams or major portions of streams.
3. Aquatic invertebrate collections were made from 32 streams in 1971 and 1972 (Zillges 1972). Collections were keyed out as far as possible with the use of a 40x binocular microscope. The collection is maintained in the office of the park research biologist.
4. The park aquatic research biologist cooperated with the Sanitary Engineering Department of Washington State University, Pullman, in a study of survival of intestinal bacteria in cold mountain streams. An initial draft report has been prepared (Johnstone and Kubinski 1973).

PLANS FOR 1974: More attention will be given to stream studies when funding becomes available in July. Stream surveys will begin in September and continue into December. Stream discharge at this time of year is generally low and will allow better access and working conditions.

References:

- Zillges, G. F. 1972. Aquatic invertebrate collections and trout stomach content analysis, 1971 and 1972. Misc. Res. Paper NOCA-3. National Park Service, 32 p.
- Johnstone, D. L., and A. M. Kubinski. 1973. Survival of intestinal bacteria in pristine waters. Project Completion Report, Environmental Engineering Section, College of Engineering Research Divison, Washington State University. 32 p.

# # #

EFFECTS OF SPORT FISH INTRODUCTIONS UPON NATURALLY FISHLESS MONTANE LAKES  
NOCA-N-12

INVESTIGATOR: C. Robert Wasem

- OBJECTIVES:
1. To determine chemical and biological changes, if any, in a high mountain lake ecosystem as a result of sport fish introductions. This would rapidly establish an exotic organism of a high trophic level in an otherwise pristine oligotrophic lake.
  2. To provide data upon which to base recommendations necessary to fulfill management objectives relating to natural area waters.

METHODS: A suitable study area has yet to be found. Present plans are to investigate two adjacent unnamed lakes of 5.04 and 0.30 ha surface area on the north side of 2418 m high McAlester Mountain in the Lake Chelan National Recreation Area to determine the existence of a fish population. If fish are not present, the two

interconnecting lakes will be rather intensively studied to measure basic water chemistry, trace elements, benthic organisms, zoo- and phytoplankton and aquatic macroinvertebrates as exist under pristine conditions. In addition, thermal profiles, depths, shoreline length and character, bottom substrates, inlet streams, outlet streams, spawning areas, etc., will be documented as is the case with all study lakes investigated under RSP NOCA-N-22.

Approximately 1000 small fingerling cutthroat trout (*Salmo clarki*) will then be released in the larger lake and their progress followed for 1 or 2 years. The lake will then be revisited at about the same stage of the ice-free season and identical studies again carried out. In addition, fish size, growth rate, condition factor, and stomach contents will be ascertained. Data from each survey would be compared with major changes in some trace elements, benthic and nectonic organisms, etc., indicating that this particular high mountain lake ecosystem has been significantly altered by the introduction and establishment of a sport fish population.

**RESULTS AND DISCUSSION:** There was no field work during the summer of 1973 due to lack of time because of higher priority projects. Arrangements have tentatively been made with the Washington Game Department to supply the cutthroat trout, and with the Sanitary Engineering Department at Washington State University to analyze water samples for trace elements and plankton. Basic water chemistry, benthic and macroinvertebrate organisms, etc., will be studied in the field and at the park's research laboratory in Sedro Woolley.

**CONCLUSIONS:** No conclusions to date except that it has been difficult to locate a study area and to get this project off the ground. Information obtained from investigating the four Diobsud Lakes in 1972 was useful for NOCA-N-22 high mountain lake ecology study.

**PLANS FOR 1974:** Visit two small oligotrophic lakes in the Lake Chelan National Recreation Area to determine suitability for this study. If it is found that fish are not present in either lake, the initial survey will be made and 1000 or so cutthroat trout fingerlings will be introduced to the larger cirque lake. If fish are present, a routine study of the two lakes will be made as a part of NOCA-N-22 high mountain lake ecology study.

# # #

MOUNTAIN LAKE ECOLOGY  
(MOUNTAIN LAKE ECOSYSTEM SURVEY)  
NOCA-N-22

**INVESTIGATOR:** C. Robert Wasem

- OBJECTIVES:**
1. To classify and describe natural aquatic ecosystems of the high mountain lakes of the North Cascades National Park and Ross Lake and Lake Chelan National Recreation Areas.
  2. To identify past and present man-caused changes to aquatic and riparian ecosystems of the high mountain lakes.
  3. To formulate management recommendations designed to maintain existing natural or near natural aquatic ecosystems of the park and two recreation areas and to maintain and improve the high quality recreational fishery in natural lakes of the two recreation areas.

**METHODS:** The principal investigator, usually accompanied by one or two biological assistants, reaches most study lakes by backpacking a round-trip distance of 5-30 miles. Survey trips usually last from 2 to 5 days. A few inaccessible lakes

outside or just on the edge of proposed wilderness have been reached by helicopter. Access to all lakes accessible or nearly accessible by trail is gained by backpacking whether or not these waters are within proposed wilderness. Many extremely remote lakes within proposed wilderness will probably never be studied because of restrictions on helicopter use to support research.

Standard techniques are employed to investigate high elevation lakes and their immediate inlet and outlet streams. Field investigative equipment is limited to that which can be carried on one's back. Monofilament experimental gill nets set overnight and angling techniques are used to capture sport fishes. Catch per unit of effort for both nets and angling is determined. The fish are sexed, weighed, and measured, and scale samples and stomach content samples taken and preserved in the field. A one-man rubber raft is employed in working nets, depth sounding, visibility measurements, making water temperature profiles, and in conducting other basic water quality measurements near lake surfaces and sometimes at lake bottoms.

The raft is also used for studying lake shorelines and visible portions of the bottom and for collecting aquatic plants, macro-invertebrates, and amphibians, etc.

Water samples are collected and, within a few days, analyzed in the laboratory for total hardness, calcium hardness, specific conductance, and turbidity.

Photographs are taken, human impact evaluated, and shoreline vegetation and character are described. Fixed-wing flights are also made several times each summer to determine stage of ice melt, for photographs, and for study of lake basins and access routes to study lakes.

Fish stomach contents are later analyzed in the laboratory and scale samples are mounted at the College of Fisheries at the University of Washington for age and growth study.

All fish collecting is carried out under a State of Washington Department of Game collecting permit.

Short progress reports on each lake are prepared for park managers and interpreters. These reports include fish condition factor and length-frequency data as well as lake diagrams and management recommendations.

**RESULTS AND DISCUSSION:** By use of 7.5 and 15 minute USGS topographic quadrangles, 230 natural lakes, ponds, and tarns have been located and catalogued in The North Cascades Complex (Wasem 1974). Only 25 of these waters (10.9%) can be reached directly by maintained trail, while access to another 20 or so (8.7%) can be gained by trail and then cross-country travel. One lake (Thunder) is on a paved road. The remaining 185 lakes (80.4%) are extremely remote and inaccessible. This remoteness, combined with a relatively short, ice-free, late summer period (mid-July to late September normally), has allowed only 32 individual lakes to be investigated to date. Five of these lakes have been visited on more than one occasion. A long, ice-free growing season, combined with an important brook trout fishery, has prompted seven field trips to Hozomeen Lake located in The Ross Lake National Recreation Area.

The author is attempting to formulate a system of classifying natural waters of the complex as based upon a number of parameters which, when combined, would indicate the severity of the aquatic environment and pristine quality. Such parameters might include elevation, aspect, shoreline aspect, surface area, mean and maximum depth, nature of bottom substrates, lake origin, and primary source of water inflow. Accessibility, past human impact, and presence of introduced fish would be measures of pristine quality. Bedrock geology and location of lake basins in relation to terrestrial vegetation life zones would be important considerations relating to potential productivity. Quantitative measure of limnetic and benthic organisms, specifically chlorophyll A, would give comparative data regarding biological activity and productivity. Water color and clarity, character of thermal and O<sub>2</sub> profiles, ionic composition, pH and alkalinity, and water circulation patterns would constitute other physicochemical parameters. Generally, the methods outlined by Hutchinson (1957) will be followed in classifying the origin of lake

Table 1. Summary of natural lakes of the North Cascades which were studied in 1973 (RSP NOCA-N-22).

Lake	Park <sup>a</sup> unit	Study dates	Elev. (m)	Surface area (ha)	Maximum depth (m)	No. of <sup>b</sup> depth soundings
1. Coon	4	3/1	662	2.40	5.25	48
2. Thunder	3	3/15	415	2.48	7.50	67
3. Hozomeen	3	6/20-22	861	38.40	18.50	142
4. Coon	4	6/26-27	662	2.40	5.25	48
5. Hozomeen	3	7/9-11	861	38.40	18.50	142
6. Bouck	3	7/24-26	1174	4.13	19.25	47
7. Ipsoot	1	7/26-28	1372	3.60	15.50	42
8. Egg	1	8/6-7	1604	0.80	5.00	24
9. Copper	1	8/7-8	1601	3.20	20.50	29
10. Jeanita	1	8/17-18	1496	0.52	2.50	22
11. Hidden	2	8/29-30	1749	20.40	61.50	14
12. unnamed (FP-9)	2	9/11	1662	0.48	<2.50	0
13. unnamed (FP-10)	2	9/10-11	1662	0.15	<1.50	0
14. Pyramid	3	9/13	802	0.17	8.75	22
15. Thunder	3	10/4-5	415	2.48	7.50	67
16. Hozomeen	3	10/24-25	861	38.40	18.50	142

<sup>a</sup>1 - North Park Unit  
 2 - South Park Unit  
 3 - Ross Lake NRA  
 4 - Lake Chelan NRA

<sup>b</sup>Total number of soundings since study began in 1971.

Table 2. Basic physical and chemical properties of high mountain study lakes of the North Cascades in 1973. Hardness, alkalinity, pH, conductivity, turbidity, and dissolved oxygen were measured 0.5 m below surface.

Lake	Hardness		Specific conductance (Mhos/cm)	pH Units	HCO <sub>3</sub> (mg/l)	Turbidity (J.T.U.)	Secchi disc (meters)	Water temp. (°C)		Dissolved oxygen (mg/l) (% sat.)	
	Total (mg/l)	Ca (mg/l)						Surface	Bottom		
Hozomeen (7/10)	57.12	47.33	107.5	8.50	53.1	0	14.0	17.7	13.4	9.4	109
Bouck (7/25)	2.86	2.45	10.0	6.60	4.0	0	12.5	12.5	4.6 <sup>b</sup>	11.0	119
Ipsoot (7/27)	4.08	3.26	12.6	6.65	4.5	3	9.5	17.5	4.4 <sup>b</sup>	8.8	107
Egg (8/8)	1.02	0.61	6.5	6.20	1.5	0	5.0 <sup>a</sup>	8.3	6.4	12.0	124
Copper (8/9)	1.22	0.82	6.6	6.40	2.0	0	17.25 <sup>a</sup>	9.0	4.9 <sup>b</sup>	12.4	130
Jeanita (8/18)	15.83	12.50	39.5	7.40	18.5	4	2.5 <sup>a</sup>	12.6	12.1	9.0	101
Hidden (8/30)	2.22	2.10	5.6	6.55	4.0	0	*	7.2	*	11.0	113
FP - 9 (9/11)	6.85	5.20	20.3	7.05	9.0	0	2.5 <sup>a</sup>	13.3	*	10.4	120
FP - 10 (9/11)	2.82	2.22	10.6	6.60	5.0	0	1.5 <sup>a</sup>	6.4	*	10.6	111
Pyramid (9/13)	37.21	31.76	81.0	7.40	39.0	7	7.25	15.1	13.8	8.8	96

<sup>a</sup>Disc resting on lake bottom and still visible.

<sup>b</sup>Water temp. at end of instrument probe at 15 m depth.

\* Not determined.

Table 3. Basic water quality near the surface (0.5m) and at the bottom of three natural lakes of the North Cascades during 1973 (RSP NOCA-N-22).

Lake	Hardness		Specific conductance (Mhos/cm)	pH Units	HCO <sub>3</sub> <sup>-</sup> (mg/l)	Turbidity (J.T.U.)	Secchi disc (meters)	Water temp. (°C)		Dissolved oxygen (mg/l) (% sat.)
	Total (mg/l)	Ca (mg/l)						Surface	Bottom	
<u>Coon (3/1)<sup>a</sup></u>										
0.5 m	10.40	9.59	22.9	6.10	*	6	*	0.2	-	4.4 33
4.1 m	15.50	14.28	36.8	6.10	*	12	*	-	4.6	1.4 11
<u>Coon (6/27)</u>										
0.5 m	12.24	9.18	27.2	6.95	13.5	10	4.0	18.5	-	10.4 102
4.0 m	10.20	8.16	27.5	6.70	13.5	14	-	-	14.6	9.2 98
<u>Thunder (3/15)<sup>a</sup></u>										
0.5 m	19.99	14.28	47.3	6.50	*	18	*	5.0	-	8.8 103
4.75 m	33.66	22.23	76.0	6.60	*	80	*	-	5.2	5.0 41
<u>Thunder (10/5)</u>										
0.5 m	38.35	28.19	86.0	7.50	39.5	4	5.75 <sup>b</sup>	13.3	-	9.8 99
5.75 m	37.68	30.62	84.0	7.60	39.5	6	-	-	13.3	9.6 96
<u>Hozomeen (6/21)</u>										
0.5 m	54.06	46.92	106.0	8.55	*	0	13.3 <sup>b</sup>	17.1	-	10.4 119
13.3 m	55.08	48.14	110.0	8.70	*	4	-	-	11.9	14.2 146

<sup>a</sup>Ice-snow-slush cover on lake.

<sup>b</sup>Disc resting on lake bottom and still visible.

\* No measurement.

Table 4. Summary of fish capture and lengths, weights, and condition factors of sport fish from nine natural lakes of the North Cascades between June and November 1973. Fish were not found in the other study lakes.

Lake	Study dates	N	Fish species	Capture rate <sup>a</sup>	Fork length in millimeters		Weight (grams)		Condition factors		
					Extremes	Mean	Extremes	Mean	K-FL Extremes	K-FL Mean	C-FL Mean
Coon	6/27-28	1	BT	0.013	--	174	--	68	--	1.291	46.60
Hozomeen	7/9-11	62	BT	0.875	150-311	211	39-310	113	0.98-1.33	1.119	40.39
Bouck	7/24-26	63	CT	0.341	108-244	188	18-147	81	0.83-1.37	1.141	41.21
Ipsoot	7/26-28	22	CT	0.056	172-360	246	63-560	246	0.85-1.25	1.078	38.92
Copper	8/7-8	6	CT	0.029	322-352	334	458-700	536	1.28-1.60	1.432	51.69
Jeanita	8/17-18	5	GT	0.079	325-340	331	390-500	456	1.08-1.32	1.252	45.22
Hidden	8/29-30	9	RbT	0.039	250-322	278	148-384	244	0.88-1.43	1.100	39.70
Hidden	8/29-30	6	GT	0.026	178-242	210	62-165	108	0.94-1.38	1.133	40.91
Thunder	10/4-5	9	CT	0.078	174-356	234	60-560	178	1.06-1.24	1.168	42.16
Hozomeen	10/23-24	99	BT	1.230	101-320	217	13-332	136	0.79-1.40	1.094	39.50

<sup>a</sup> Mean no. fish captured per hour per 100 ft<sup>2</sup> of gill net.

BT = brook trout; CT = cutthroat trout; GT = golden trout; Rbt = rainbow trout.

basins, lake morphometry and morphology, and physicochemical properties of lentic waters.

PLANS FOR 1974: Continue the study with first-time survey trips planned to the following lakes: Middle Thornton, Upper Thornton, Sourdough and unnamed tarn (MP-10), Trapper, Battalion, Stiletto, (MC-15) 2 unnamed lakes on McAlester Mtn. (NOCA-N-12 study), unnamed tarn on Copper Ridge (MC-5), unnamed tarn near Hidden Lake (EP-14). The following lakes may be revisited: Hidden, Lower Thornton, Copper, Doubtful, Ridley, Hozomeen, Thunder, Coon.

References:

Hutchinson, G. E. 1957. A treatise on limnology, 1015 p. John Wiley & Sons, New York.  
Wasem C. R. 1974. Topographic map survey of reservoirs, lakes, ponds, and tarns of the North Cascades National Park Service Complex, Washington. Report in preparation.

# # #

ROSS LAKE STUDIES

INVESTIGATORS: Robert L. Burgner )  
William Parr )  
P. Michael Pease ) Fisheries Research Institute  
Anthony Oppermann )  
Rodney Woodin )

SUMMARY OF PROGRESS: Additional information on timing and distribution of spawning in the Ross Lake drainage was obtained through a fish sampling program begun in April and continuing through September.

Scale samples of fish from Ross Lake and tributary streams were collected along with data on length, weight, sex, and maturity. Analyses of these data are being made to determine scale patterns and growth of lake versus stream fish.

Studies of abundance and sport catch trends in Ross Reservoir were continued in 1973. Population estimates using tagging and recapture techniques are being made. Creel census was conducted throughout the fishing season.

Additional information which may be useful for predicting survival potential of fertilized trout eggs inundated to varying depths by rising lake level was obtained in 1973. Artificially fertilized eggs from ripe native Ross Lake rainbow trout were placed in containers and buried in lake shore gravels near stream inlets.

The feasibility of transferring artificially fertilized trout eggs from spawning areas which would be inundated by the proposed reservoir to stream areas above the level of the proposed reservoir was explored through an incubation-box experiment. Survival of the transplanted eggs was compared to that of eggs native to the control stream. Transplantation of eggs is a possible method of assuring full utilization of spawning grounds which would become available if the reservoir is raised to the 1725 ft elevation.

Expanded studies of limnological conditions of Ross Lake, Diablo Lake, and Gorge Lake were begun in 1973. Included were water quality analyses, measurements of abundance of primary producers, zooplankton, and benthic fauna. Stomach samples from trout and char in Diablo and Gorge lakes were collected to compare the composition of their diet to that of the food supply.

Results of studies through 1972 were incorporated in Interim Report No. 2, Vol. I and II of the International Skagit-Ross Fishery Committee, dated May 1973.

SIGNIFICANT FINDINGS: Trout fry abundance in the spawning tributaries to Ross Lake as measured by systematic fykenet sampling was distributed as follows:

	Total	Percent	Below 1725
Skagit River <sup>a</sup>	129,025	(44.7)	42,556
Lightning Creek	52,416	(18.2)	52,416
Dry Creek	10,280	( 3.5)	10,280
Roland Creek	23,046	( 8.0)	23,046
Big Beaver Creek	604	( 0.2)	-
Ruby Creek	73,321	(25.4)	6,232
<b>Total</b>	<b>288,692</b>		<b>134,530</b>

<sup>a</sup>Fry production figures for the Canadian Skagit River were determined by F. F. Slaney & Co. Ltd.

The spawning fish which produce fry below the 1725 ft elevation would need to move farther upstream to spawn if the reservoir is raised as proposed; however, there is ample evidence that the spawning fish would adapt to this shift in location of the spawning gravels. In each of the streams mentioned above, except Big Beaver Creek, spawning gravels above the 1725 ft elevation would be available to fish from Ross Lake. It appears from the above that Big Beaver Creek does not support a significant portion of the spawning by trout from Ross Lake.

Analyses of the scale, length, weight, sex, and maturity data are in progress. Preliminary results indicate that time of trout spawning is relatively constant from year to year (April-August, with the peak in early June). Generally, the growth rate in length of a fish is greatest in its second year but its greatest growth in weight is in its 3rd year. Average length and weight at each annulus is approximately as follows: Age I - 60 mm, 2.5 g; Age II - 220 mm, 120 g; Age III - 310 mm, 335 g; Age IV - 355 mm, 475 g; Age V - 378 mm, 565 g.

Population estimates and catch statistics for 1973 are not yet completed. Preliminary results indicate that catch per unit of effort (catch per angler hours) in 1973 was similar to that in 1972 (0.56) and 1971 (0.49).

Results of the egg survival experiments indicate that egg survival to fry emergence in inundated gravels off stream mouths is variable and generally is adversely affected, but survival can occur under certain conditions in gravels flooded to 30.5 ft depth.

The results of the experimental transfer of artificially fertilized trout eggs from a stream area to be inundated to another stream showed no significant difference in survival to the alevin stage (about 90%) between the transferred eggs and those from the control stream. Artificial fertilization and transfer of trout eggs appear to be a very useful means of assuring utilization of newly available spawning areas by spawners presently spawning below the elevation of the proposed reservoir.

Limnological conditions and the food supply of the game fish in Ross, Diablo, and Gorge lakes were studied intensively in 1973 so that baseline conditions in these reservoirs will be established before any changes occur due to the proposed High Ross Dam. Summarized, the results of this work indicate that the nutrient level standing crop of phytoplankton, zooplankton, and benthos are quite low compared to other cold, deep lakes in Alaska, British Columbia, and Washington State. These lakes are typical highly oligotrophic lakes.

The results of cooperative studies by the Fisheries Research Institute and other agencies of the International Skagit-Ross Fisheries Committee in 1973 will be included in an additional joint interim report (No. 3) which will be completed in the first half of 1974. The research has provided the data necessary for assessment of present conditions in the aquatic environment of the Ross, Diablo and Gorge lakes drainages, for forecasting the probable effects of a change in the maximum reservoir elevation from 1602.5 to 1725 ft, and for establishment of a data base for measuring the effects if the reservoir is enlarged. Evaluation of the information to date has shown that if the reservoir level

is increased, adverse effects on the spawning success of the trout population can be prevented by improving accessibility of spawning areas which are presently inaccessible to spawning trout from the Ross Lake population.

PLANS FOR 1974: The scope and objectives of research plans for 1974 on Ross, Diablo, and Gorge reservoirs are expected to be similar to those in 1973. The sport catch and effort will continue to be monitored to detect trends in population size.

It is anticipated that attention will be directed at potential effects of temperature changes in the Skagit River below Gorge powerhouse particularly as related to development of juvenile salmonid species and their food supply. Continued attention will be given to specific potential problems which may arise if Ross Lake is elevated to a maximum of 1725 ft and methods which could be implemented to mitigate any adverse effects resulting from these problems.

# # #

INVESTIGATOR: Albert E. Grable (UNTITLED)  
Walla Walla College

SUMMARY OF PROGRESS: Due to limited time in 1973, sampling was done only at one location, near Happy Creek south of Highway 20. All collecting was done on 9 July. Although the permit also included insects, only vascular plants were collected. Data obtained were basically baseline in comparison for the future.

# # #

#### PREPARATION OF MAMMAL AND BIRD STUDY SKINS

INVESTIGATOR: Ruth E. Shea

SUMMARY OF PROGRESS: Have so far prepared five mammal and eight bird skins.

# # #

#### HEPIALID MOTHS AND HIGH ALTITUDE BUTTERFLIES STUDY

INVESTIGATOR: Norman B. Tindale  
South Australian Museum

SUMMARY OF PROGRESS: The Hepialidae are elusive and appear only for very limited periods. Many mountain areas have been visited over the past 10 years and several new species have been discovered. In Australia, similar rare species suddenly become economic pests after the artificial fertilization of grasslands. No specimens were found in 1973 in the North Cascades although they are known on Mt. Rainier. One species was detected in Arizona. The adjunct study, that of Alpine butterflies, enables the best use to be made of research time. During the early summer visit to the North Cascades, an arctic Canadian species (*Boloria freija*) was taken, for only the second

occasion within the United States, on the Upper Stehekin River. I hope to visit the area again.

# # #

RESERVOIR ECOLOGY (RESERVOIR ECOSYSTEMS AND SPORT FISHERIES)  
NOCA-N-24

INVESTIGATOR: C. Robert Wasem  
National Park Service

SUMMARY OF PROGRESS: This project is not scheduled for official funding until 1 July 1976. However, some preliminary studies are in progress as follows:

1. Physical and chemical limnology of Thunder Arm of 364 ha Diablo Lake has been studied during 1972 and 1973 with the purpose of relating pH, total and calcium hardness, specific conductance, secchi disc visibility, turbidity, and thermal profiles with Thunder Creek discharge and glacial melt in the Thunder Creek drainage. The above parameters have been measured at four stations every 2 weeks between 1 April 1972 and November 1972, and between 30 May 1973 and 19 November 1973. Weather records and USGS discharge data for Thunder Creek are needed to complete the 2-year study. A progress report will be prepared this winter.
2. Periodic limnological measurements have been made in 84 ha Gorge Lake during 1972 and 1973.
3. Longitudinal gradient profiles of all permanent streams draining into Gorge Lake, Diablo Lake, and the head of Lake Chelan have been drawn as based upon 7.5 minute USGS topographic maps. Basic water quality of most of these streams has been determined.
4. Studies at the head of Lake Chelan have been of three types as follows:
  - a. Physical and chemical limnology, similar to investigations on Thunder Arm but including dissolved oxygen, has been studied at four stations in mid-lake in June 1972 and June 1973.
  - b. Fish fauna studies by use of five gill net sets were continued from June 1972. Eighty-two fish representing six species and four families were taken. A listing follows:

<u>Species</u>	<u>No.</u>	<u>%</u>
Rainbow trout ( <i>Salmo gairdneri</i> )	4	4.9
Burbot (ling) ( <i>Lota lota</i> )	1	1.2
Peamouth ( <i>Mylocheilus caurinus</i> )	9	11.0
Northern squawfish ( <i>Ptychocheilus oregonensis</i> )	26	31.7
Largescale sucker ( <i>Catostomus macrocheilus</i> )	14	17.1
Longnose sucker ( <i>Catostomus catostomus</i> )	28	34.1

The same species listed above plus four kokanee salmon (*Oncorhynchus nerka*) were collected in June 1972 with five overnight monofilament gill net sets. Cutthroat trout (*Salmo clarki*), Dolly Varden charr (*Salvelinus malma*), and mountain whitefish (*Prosopium williamsoni*) have not been captured to date at the head of Lake Chelan even though cutthroat and Dolly Varden are known to exist in this lake.

- c. The kokanee salmon is the most important sport fish in Lake Chelan. Kokanee spawning in the Company Creek above Lake Chelan has been studied over the past 3 years. In early November 1973, 147 fish were captured and lengths, weights, condition factors, and fecundity determined. Unspawned females averaged 442 eggs. Males averaged 257 mm fork length and 186 g in weight. Females averaged 253 mm fork length and 166 g weight. Since November 1971 both spawning males and females have shown gradual increase in size. Males have increased 11.5% in from length and 38.3% in weight, while females have shown a similar increase from 1971 to 1972 to 1973. Size increase may be due to better food supply, particularly as a result of introductions of the opossum shrimp (*Mysis relicta*) in 1968 and again in 1971. The State Game Department introduced these crustaceans from Kootenai Lake, British Columbia. Success of the *Mysis* introductions has not been evaluated to date.

Progress reports of all phases of Lake Chelan Study are being prepared.

# # #

#### STUDY OF NEOGLACIAL MORAINES AT PRICE LAKE

INVESTIGATOR: Eric Leonard  
Simon Fraser University

SUMMARY OF PROGRESS: Have been able to develop a chronology of glacial activity since the Pleistocene which appears to accord reasonably well with other in the Cascade Range. Also have conducted test of the use of lichen size as a dating technique which indicates that in spite of certain problems the technique appears promising.

Price Lake is less than 60 years old.

# # #

#### SURVEY OF THE ARACHNID FAUNA OF WASHINGTON

INVESTIGATOR: Rod Crawford  
University of Washington

SUMMARY OF PROGRESS: Due to the fact that I must depend on others for my transportation, no collecting has been done in any national park this year. Hopefully, it will be possible to do some collecting in the park next year and in subsequent years.

## NORTHEAST COAST

### DISTRIBUTION AND OCCURRENCE OF BIRDS ON THE NORTHEAST COAST OF THE UNITED STATES

INVESTIGATOR: P. A. Buckley

OBJECTIVES AND METHODS: To record information, from places where it is spotty or lacking, on the distribution and occurrence of birds, especially waterbirds, in various areas where I have occasion to frequent, notably CAHA, CALO, FIIS, GATE, and CACO. This information is passed on to park officials, to regional editors of ornithological journals, or prepared for publication. It also forms a basis for evaluation of avian data from within NPS areas in relation to regional trends and population phenomena.

In addition, I have been continent-wide editor for the winter Changing Seasons column for *American Birds* since the winter of 1970-71. However, this editorship was given up after completing the 1972-73 report as I accepted the regional editorship of the Hudson-St. Lawrence region for *American Birds*.

RESULTS: Most of the results of my observations are listed in the papers enumerated below, although some appear elsewhere, as in some area checklists.

PLANS FOR 1974: To continue observations in the manner indicated, including writing the column four times a year for *American Birds*; to write up a short note on the first North American occurrence of Bahama Mockingbird at FOJE in May 1973; to write up observations on previously unknown seabirds from the Gulf Stream off CAHA; to prepare a bird checklist for GATE; and to work up some additional distributional notes for various journals. Much of the data from this and past, similar studies will also be used in working with Master Plans, EIS's, Resource Management Plans, etc., for various seashore parks, especially those listed above. In addition, I hope to be able finally to pursue detailed statistical analyses of data from the Montauk Pt., L.I., N.Y. Christmas Bird Count (of which I was compiler from 1959 to 1972), going back to the first in 1920, and from the more recent Captree Christmas Count (of which I was compiler from 1970-72), going back only 10 years but embracing FIIS.

#### Publications:

- Buckley, P. A. 1973. A preliminary check-list of the birds of the Fire Island National Seashore area. (Prepared for park distribution) 5 p.
- \_\_\_\_\_. 1973. A massive spring (seabird) movement, including three species new to North Carolina, at Cape Hatteras National Seashore. *American Birds* 27:8-10.
- \_\_\_\_\_. 1973. The changing seasons: winter of 1972-73. *American Birds* 27:578-85.
- \_\_\_\_\_, and T. H. Davis, Jr. 1973. The Hudson-St. Lawrence region (summer season 1973). *American Birds* 27:845-52.
- Davis, T. H. Jr., and P. A. Buckley. 1974. The Hudson-St. Lawrence region (fall migration 1973). *American Birds* 28:in press.

# OLYMPIC NATIONAL PARK

## ECOLOGY AND MANAGEMENT OF NONNATIVE MOUNTAIN GOATS IN OLYMPIC NATIONAL PARK OLYM-N-15

INVESTIGATOR: Bruce B. Moorhead  
Olympic National Park

OBJECTIVES: To determine the vital characteristics, distribution, and habitat relationships of a mountain goat population introduction to the Olympic Mountains 1925-29, or about 10 years before the park was established.

SUMMARY OF PROGRESS: On 19 foot trips, which included 35 field days and 4 climbs of Mt. Angeles, 456 mountain goat observations were analyzed for population structure, seasonal movements, and habitat uses. Two aerial counts, spring and fall, were conducted over Mt. Angeles and the eastern ranges of the park. The Mt. Angeles population, the largest concentration in the park, is now estimated to number 90-120 animals. Composition data indicate 80+ kids/100 adult females. Two sets of twins were found in 1973. One of the females with twins was marked in July 1972 as a nonparous subadult. Kid mortality on Mt. Angeles is apparently as high as 80% during the first winter, but thereafter drops off to less than half that figure in other subadult classes. In two October composition counts the subadult classes (including 52 kids) comprised 58% of 128 goats observed. Seasonal movements of eight color-marked animals have confirmed winter-summer migration of 4-5 linear miles and 300 ft elevational changes. Four goats were transplanted from Mt. Angeles to Gifford Pinchot National Forest, in south-central Washington, in a cooperative project with the U.S. Forest Service and Washington Department of Game.

PLANS FOR 1974: This was the 3rd year of a 6-year project to obtain basic data for management about a nonnative population of mountain goats. Population monitoring on Mt. Angeles will continue in 1974, plus extended trips to assess the population-at-large in the park. A manuscript will be completed for journal publication entitled Introduction and Dispersal of Nonnative Mountain Goats in Olympic National Park.

# # #

## MANAGEMENT STUDIES OF HUMAN IMPACT UPON THE ECOSYSTEMS OF OLYMPIC NATIONAL PARK OLYM-N-16

INVESTIGATOR: Bruce B. Moorhead

OBJECTIVES: To conduct an extensive survey throughout the park of the various sites used recreationally; to evaluate the amounts and severity of evident site damage due to human uses; and to recommend needed research and improved management practices indicated by the results obtained in this initial study.

SUMMARY OF PROGRESS: Initial trial impact surveys were completed along major sections of the following trail systems: Skokomish, Duckabush, Dosewallips, Quinault, Soleduck, Hoh, and Elwha. Campsite impact studies focused on 14 high lakes: Flapjack, Marmot, Hart, Constance, Elk, Hoh, Lunch, Round, Clear, Deer, Boulder, Gladys, Moose, and Grand. Investigative activities included photo-inventory, site mapping, plant and canopy cover composition, trampling, erosion and tree damage indices,

and permanent vegetation trend plots. Aerial oblique photos were taken to assist site mapping and trend monitoring. Impact studies at three "frontcountry" vehicle campgrounds included erection of fenced exclosures, site cover mapping, photo-inventory, and installing permanent vegetation-intercept trend plots.

PLANS FOR 1974: Investigations in 1974 will concentrate on significant problem areas such as Seven Lakes Basin, Grand Valley, and the Elwha-Quinault trail corridor. Publication plans include a 1975 paper on Recreational impact in a moist coniferous wilderness park, with implications for protective management.

# # #

## VEGETATION DYNAMICS AND HUMAN TRAMPLING PNWR-N-1

INVESTIGATORS: Garrett A. Smathers)  
Edward P. Schreiner) University of Washington

OBJECTIVES: The purpose of this project is to further our understanding of the relationships between human trampling and site conditions. The work is being conducted primarily in Olympic National Park in the Deer Park Area. Additional study sites are under investigation in North Cascades National Park. A major emphasis of the work is to obtain information to aid resource managers in making decisions concerning human use and site conditions in regional national parks.

METHODS: An examination of vegetation response to human trampling with reference to species cover and plant life forms was made. Plots at Deer Park were trampled by the investigator permitting controlled investigation of trampling stress. Trampling was held constant for each of three subalpine meadow types: dry, mesic, and moist.

Tools used for analysis included photographs, plant biomass samples, and samples of vegetation cover.

Additional work was conducted using photographs and field observations at several heavily used sites in other areas of Olympic National Park. These sites included Staircase, Hoh River, Seven Lakes Basin, and Kalaloch. Observations were also taken at Easy Pass, Cascade Pass, and Colonial Creek Campground in North Cascades National Park.

SUMMARY OF PROGRESS: The 1973 season was used to examine areas other than Deer Park (in both Olympic and North Cascades national parks) to determine if other trends were discernible where site conditions and trampling were concerned. All of the areas mentioned (except Cascade Pass) in the methods section were examined in 1973.

Plots trampled at Deer Park in 1972 were resampled to determine what course vegetation recovery had taken after trampling was discontinued.

SIGNIFICANT FINDINGS: Deer Park: Data recorded from the field season of 1972 seem to indicate that grasses and sedges are slightly more resistant to trampling than other plants. The response of vegetation to trampling is highly variable, depending on the species present and site conditions. *Arenaria capillaris* and some grasses and sedges were the more resistant species. *Phlox diffusa*, *Campanula rotundifolia*, *Luetkea pectinata*, *Lupinus latifolius*, *Antennaria lanata*, and *Hieracium gracile* were among the most susceptible species. The life form of the plants present was related to the extent of alteration by trampling in some cases and in others the classification scheme seemed to break down. Leaf and stem characteristics were apparently more important than life form in some cases. Plants with wiry, resilient stems withstood

trampling better than soft- or brittle-stemmed species. The length of the petiole also seems important.

Data collected from the summer of 1973 indicate that *Arenaria capillaris* may be a significant pioneer of trampled sites on dry meadows.

Staircase and Seven Lakes Basin: These areas have received little or no management over the last 40 years. The sites at Staircase campground are largely barren of vegetation and many secondary trails and sites have been established in the Seven Lakes Basin area. Species characteristic of "waste areas" are present at Staircase in relatively high numbers. These species are replacing the native vegetation in certain sites.

Hoh River Trail: The Hoh River trail contains several large mudholes. These were found to be related to soil types. Planning the trail location with regard to soils could have avoided many of the present problems of mudhole formation.

RECOMMENDATIONS: Work concerning vegetation and human trampling should be continued. (Using information to date plus added specific data concerning leaf forms and stem characteristics.) It is believed that a basic relationship between vegetation response and trampling may be uncovered, if present and future data on leaf and stem characteristics are employed. This relationship should be useful to resource managers throughout the National Park System.

The project should be expanded to include physiological studies of resistant and susceptible species to determine if there are important differences causing relative resistance and susceptibility. This aspect of the study would endeavor to discover some of the "whys" relative to differential responses of species. This could be especially important in determinations of those species to be used for site recovery.

Further work is needed to understand the relationships between vegetation recovery and existing site conditions. Many methods have been tried throughout the National Park Service and U.S. Forest Service. The problem is that such information is not available for general use. It should be synthesized and the more promising techniques tested.

# # #

VEGETATION DYNAMICS AND HUMAN TRAMPLING OF SUBALPINE ECOSYSTEMS OF  
OLYMPIC NATIONAL PARK AT DEER PARK  
PNWR-N-2

INVESTIGATORS: Edward G. Schreiner) University of Washington  
Garrett Smathers )

SUMMARY OF PLANT LIFE FORMS: Plant life forms were hypothesized to be a primary basis for which the relative resistance or sensitivity of plant species to trampling could be predicted. Present data indicate this system to be on the right track but needs modification for complete applicability to resource managers. Future work in this respect will entail classification of plant species by their leaf form and size. Plant physiological characteristics concerning root penetration ability will also be considered.

The 1973 season was spent synthesizing data collected the previous year into a Masters Thesis. (Part I indicated above as about 95% complete at present).

Following completion of the thesis, a paper will be written, and published jointly with NPS and College of Forest Resources, that interprets the data and thesis work for use directly by Resource Managers.

Additional work in 1973 included examination of various compgrounds around Olympic National Park as to the condition of vegetation in them. These included primarily Staircase and Hoh River campgrounds. The Hoh River trail was also examined in terms of the relationship of soils to quagmire development. Severn Lakes Basin area and Deer Lake were also examined to obtain information pertaining to vegetation and soil conditions. The plots established at Deer Park were reexamined for information pertaining to plant recovery in areas previously trampled.

Future work will entail primarily the narrowing of the above mentioned hypothesis to gain further insights useful to Resource Managers concerning the relationship of plant sensitivity and resistance to human trampling.

# # #

## BLUE GLACIER PROJECT OLYM-N-7

INVESTIGATORS: Edward R. LaChapell)  
Charles Raymond ) University of Washington

SUMMARY OF PROGRESS: The Blue Glacier Project maintained an active field program for approximately 2 months from early July until early September 1973. The station on the Snowdome was manned continuously during this time. Normal climate and glacier mass balance observations were maintained as in past seasons, extending to the 16th consecutive year the documentation of annual accumulation, ablation, and mass balance of this glacier.

A reduction of NSF funding this year resulted in a more austere scientific program than in recent years. The main emphasis was on student projects related to the general thrust of recent research on the thermodynamic perperties and structure of temperate (isothermal) ice.

In August, a study was made of the gas (air) in coarse bubbly ice of White ojive bands in the Lower Blue Glacier. The amount of gas (reduced to 1 atmosphere pressure), its *in situ* pressure, and the percent void volume, were measured. Air pressure found in these samples was typically 3 atm. A control sample taken from the Snowdome recorded a pressure only slightly higher than ambient. The air pressure in the bubbles is strongly related to the thermal regine of the ice, and may explain otherwise puzzling temperature measurements. Analysis is currently underway to determine if the measurements are real of if they are due to instrumental effects. Investigations are being conducted to determine the relationship between pressure and temperature and the significance of the results if they prove to be true.

At the same time a different experiment was performed on the Snowdome. The percolation rate of water through a chunk of ice was studied under stress and thermal conditions which differed as little as practical from those in the glacier. A small amount of a standardized, dilute solution of rhodamine red dye was introduced to the top of the sample in a snow-ice cave. Drip samples were collected after determined time intervals to be analyzed at the University of Washington. No conclusive results are available yet, but they may be important in estimating water flux through intercrystalline microchannels.

Results from the 1973 mass balance measurements and observations are especially interesting. Although this was a year of abnormally low snow accumulation in western Washington, this situation had surprisingly little effect on the Blue Glacier. The calculated specific net mass balance for the end of the ablation season in mid-October gives a value of +0.1 m water equivalent. The magnitude of the quality lies well within observational errors, so there is a chance that the mass balance was in fact slightly

negative. In any case, the mass balance did not depart far from equilibrium in even this dry snow year. The ice ablation during the summer was not abnormally high, while the snow accumulation on the upper glacier was substantially larger than general snow patterns this year in the Cascades and Olympics might have indicated. It appears that much of the precipitation which fell as rain early in the winter of 1972-73 at lower elevations must have fallen as snow above about 6000 ft.

The photo station at the Blue Glacier terminus was occupied once again and the glacier position measured. There has been no large change (advance or retreat) of the terminus position. We have noted, however, that a definite thickening is taking place in the ice near the terminus. This is especially noticable at the access point to the Glacier Meadows trail, where the thickening has become very obvious over the past 2 years and now amounts to 50-75 ft (15-20 m).

Aside from the field work, a considerable amount of data reduction and paper writing based on accumulated field work of previous seasons has been accomplished in the past 6 months. At least two papers dealing with the recent studies on temperate ice are now almost ready for submission to scientific journals.

# # #

FOREST VEGETATION OF OLYMPIC NATIONAL PARK  
OLYM-N-18

INVESTIGATOR: Richard W. Fonda  
Western Washington State College

SUMMARY OF        The initial investigation into forests in the Hoh Valley is complete. A  
PROGRESS:        manuscript has been submitted to *Ecology*, and should appear in press  
                  this year.

An associated project, communities of the coastal Sitka spruce zone, is to be completed by June 1974. All the field work is complete, unless it becomes necessary to check some inconsistency appearing in the analysis of the data. Vegetational analysis is in progress, and should be completed by February; soil analyses should also be completed by about that time.

Tentatively, the coast Sitka spruce zone has been broken into seven main habitat types based on understory composition:

1. Sitka spruce/false lily of the valley
2. Sitka spruce/sword fern
3. Sitka spruce/salal
4. Sitka spruce/moss
5. Sitka spruce/sedge
6. Sitka spruce/skunk cabbage
7. Sitka spruce/salmonberry

These habitat types are distributed throughout the length of the coastal zone in the park. While we do not yet know all the controlling factors sorting out the different types, our best guess at this point is that water availability will be the major factor.

I believe that this project number should be kept in an open category because there is much that can still be investigated in the forests of the park.

## ECOLOGY OF ALPINE TIMBERLINE

INVESTIGATOR: Richard W. Fonda  
Western Washington State College

SUMMARY OF PROGRESS: The timberline investigation is proceeding well, but to continue now needs funding by NSF or some other granting agency. For 2 years we have gathered preliminary data on environmental and physiological processes, and have an analytical diagram that shows what we believe to be happening to form the timberline in the Olympics. Future research will test each of these hypotheses and will strive to uncover new ones, but with the funding and equipment we now possess, it is impossible to go much further.

Two associated projects (Canada: Control of plant production, phenology, and distribution by a subalpine snowbank microenvironment; and Wood: Habitat selection and energetics of the Olympic marmot) are finished, and copies of the thesis have been submitted to the park. Currently the manuscripts are being rewritten for publication.

Two other projects are currently being worked on. Jerry Householder is following the seasonal progression of carbohydrates in the subalpine meadow species at timberline, in order to correlate energy reserves with specific environmental and phenological events. Samples of shoots, roots, and rhizomes were taken about every 3 days during summer 1973, and these are now being analyzed quantitatively for sugars and starches. We will not know what the seasonal pattern is until he finishes these analyses.

Mark Sheehan is studying the food habits of *Microtus oregoni* and *Microtus longicaudus* in the subalpine and upper montane forests zones. In summer 1973 a total of 21 *M. oregoni* and 19 *M. longicaudus* were trapped. Initial trapping results indicate that *M. oregoni* is found primarily in tall sedge communities and related areas of the subalpine meadow zone. *Microtus longicaudus* was trapped at lower elevation along stream banks, avalanche chutes, and other areas close to running water. Trapping took place primarily around Mt. Angeles, Hurricane Ridge, and Obstruction Peak. Another summer of trapping is necessary to determine with greater accuracy the actual food and habitat preference.

Examination of stomach content by microscope to determine food preference is underway at the present time.

Also trapped:

- 1 *Phenacomys intermedius*
- 1 *Clethrionomys gapperi*
- 6 *Sorex palustris* (nontarget)
- 10 *Zapus trimotatus* (nontarget)
- 25 *Sorex vagrans* (nontarget)
- 40 *Peromyscus maniculatus* (nontarget)

# ORGAN PIPE CACTUS NATIONAL MONUMENT

## INTERRELATIONSHIPS OF LIGHT AND GREEN ALGAE IN OREGON CAVES ORCA-N-1a

INVESTIGATORS: James A. Blaisdell)  
Herbert Curl ) Oregon State University

OBJECTIVES: Green plants, including algae, mosses, and ferns, are present and growing unnaturally in Oregon caves because of artificial lights. The lights are in the form of incandescent lamps installed for the safety and comfort of the visitors as well as for special lighting effects of cave features. The objective is to find a way to light the cave without encouraging the growth of plants.

METHODS: Natural conditions in the cave preclude the desirability of harboring such green plants. Types of research aimed at their control are:

1. Because the ultra-violet lamps proved impractical, and new lighting system installation was begun prior to the completion of all tests possible, it was decided to eliminate lighting tests.

2. From this point we will proceed with control tests using chemicals.

RESULTS AND DISCUSSION: Unfortunately, information promised by former assistants in the program was never received, nor do we seem able to get any of the data collected. We, therefore, have enlisted the aid of Dr. Herbert Curl, Oregon State University. He has made one trip to the area and has prepared initial recommendations for algae control. One good feature of fluorescent lighting is that less heat is generated, and perhaps less growth of algae. We now propose, as a result of Curl's studies, to test certain chemicals in three portions of the cave. The chemicals presently proposed are Diuron (DCMU) which affects one enzyme in photosynthesis, copper sulfate ( $\text{CuSO}_4$ ), which controls algae growth in water, and Zephiron which affects cell membranes and controls algae, bacteria, and fungus. These will be placed on some walls in "patch" tests and their actions documented by photography.

PLANS FOR 1974: Chemical tests and documentation.

# # #

## RESOURCE RECONNAISSANCE OF THE GRAN DESIERTO REGION, NORTHWESTERN SONORA, MEXICO

INVESTIGATOR: Larry A. May  
Denver Service Center

SUMMARY OF PROGRESS: The purpose of the study was to inventory the natural, physical, and cultural resources of the Gran Desierto Region of Sonora, Mexico, adjacent to Organ Pipe Cactus National Monument to assist in the justification of the protection and preservation of this unique arid environment. Resources of the Gran Desierto discussed in the report include: the geology, potable free-water surfaces, climate, biological resources, archeology, and current land-use patterns of the region.

Lic. Horacio Gallegos Gamiochipi, Director of the National Commission of Public Works in Natural Parks of Mexico, has incorporated this report in a master plan that will set a major portion of the Gran Desierto aside as a natural park and reserve, possibly with international coupling with Organ Pipe Cactus National Monument in Arizona.

Publications:

- May, L. A. 1973. Geological reconnaissance of the Gran Desierto Region, Northwestern Sonora, Mexico. *J. Ariz. Acad. Sci.* Vol. 8. No. 3.
- \_\_\_\_\_. 1973. The Gran Desierto of Northwestern Sonora, Mexico. Paper presented to the Conference on the Borderlands in San Antonio, Texas, October 26-27, 1973. Transactions in press.
- \_\_\_\_\_. Estudio Sobre El 'Pinacate,' Gran Desierto de Sonora. Comision Nacional de Obras en Parques Naturales (CONOPAN-SOP). Mexico, D.F.

## OZARK NATIONAL SCENIC RIVERWAYS

### COMPREHENSIVE WATER QUALITY STUDY FOR OZARK NATIONAL SCENIC RIVERWAYS

INVESTIGATOR: Jim Barks  
U.S. Geological Survey

SUMMARY OF OBJECTIVES: Objectives of this study were to: (1) document the existing physical, chemical, and biological condition of the streams and springs in the Riverways; (2) detect and investigate areas of anomalous water quality; and (3) determine the influence of visitor-use on water quality in heavy-use areas.

A mobile laboratory was used for the collecting, preservation, and transportation of water samples in the field. Comprehensive analyses were made for 24 sites during 1973 to provide a synoptic view of water quality. Four key sites were selected for repetitive sampling to show variations with time, run-off, and area uses. These sites were sampled quarterly for physical chemistry, trace metals, and basic biological analyses, and bi-weekly during the summer for pesticides. In August, a diel study was made on the Jacks Fork above and below the Alley Spring Campground. Water temperature, dissolved oxygen, and bacteria were measured at 2-hour intervals for 24 consecutive hours. Although field determinations were made for properties which change rapidly, most samples were analyzed at specialized USGS facilities in four states. The data have been stored in the main Water Resources Division computer file in Reston, Virginia, for later retrieval. Data collection for the 1973 calendar year was completed in November.

During 1974, key sites will again receive comprehensive analysis on a quarterly basis. However, the frequency of nutrient samples will be reduced. Instead, intensive short-term studies will be made at selected areas, particularly during the summer.

# # #

### FLOOD DAMAGE TO ALLEY SPRING DEVELOPED AREAS

INVESTIGATORS: L. F. Marnell )  
R. N. Smith ) National Park Service

SUMMARY OF           Recent channel changes in the Jacks Fork River above and below the Highway  
PROGRESS:           106 bridge have allowed flood waters to invade the Alley Spring developed  
                      area and cause extensive damage to property and facilities maintained by  
the National Park Service. Upstream from the bridge, the channel has cut to the west  
and eroded into a major campground and day-use area. Rapid erosion is taking place and  
tons of loose gravel have been spread over campsites. Below the highway bridge, flood  
waters have cut several erosion gullies into a major day-use area and transported large  
quantities of gravel across roads and picnic sites. A loop of the Alley Spring branch  
has been invaded and gravel deposition is occurring.

The flood and erosion situation has catastrophic potential in this area because camp-  
ground and day-use facilities at Alley Spring are currently undergoing renovation. During  
the summer and fall of 1973, aerial and ground reconnaissance was carried out to provide  
photographic documentation of the problem area. A plan is being formulated for corrective  
measures. The project will involve removal of willow thickets and other vegetation  
obstructing the main channel and diversion of a small section of river back into its  
original channel. An Environmental Assessment for the proposed work is under preparation.  
The project will be carried out by National Park Service Personnel.

# # #

#### FISHERY CREEL SURVEY

INVESTIGATOR:   L. F. Marnell  
                  National Park Service

SUMMARY OF           For the second year, the National Park Service conducted a summer creel  
PROGRESS:           survey on the Current and Jacks Fork rivers to obtain information con-  
                      cerning angler success, catch composition, and fisherman characteristics.  
Basic biological data were also secured for certain species of fish. Approximately 800  
boat and bank fishermen were contacted by a seasonal clerk who traveled by canoe 5 days  
per week.

The purpose of the creel survey is to provide a basis for management recommendations  
made annually to the Missouri Conservation Department. The survey is still experimental  
since different sampling procedures are being tried to produce reliable data in an  
efficient manner. Once sound methods are established, the survey will be continued on  
an operational basis for annual monitoring of fishery trends. Major problems have been  
in the area of field logistics and also the low educational level of Ozark fishermen  
has created difficulties in the gathering of reliable data. The 1973 phase of the  
project was altered from the preceding year by (1) reduction from a two-man to a one-man  
operation; (2) cessation of attempts to quantify fishing pressure; and (3) addition  
of a 20-mile section of the Jacks Fork to the existing 48 miles sampled on the Current  
River.

Plans for the 1974 survey are under review pending evaluation of data obtained during  
1973.

## MANAGEMENT OF OPEN FIELD HABITAT FOR WILDLIFE

INVESTIGATORS: National Park Service and  
Missouri Conservation Department

SUMMARY OF PROGRESS: Numerous tracts adjoining the Current and Jacks Fork rivers were formerly cultivated for production of corn, milo, and legume hays. However, hay and row crop farming has declined due to a shift in the regional economy from subsistent agriculture to tourism and recreation. Inclusion of many of these fields within Ozark National Scenic Riverways also contributed to the abandonment of farming in bottom lands along the Current River. Consequently, many fields have lain fallow for several years and some are on the verge of reverting back to stubble and undergrowth.

The Master Plan and Enabling legislation for OZAR, as well as existing agreements between the National Park Service and the Missouri Conservation Department, all strongly endorse the concept of wildlife habitat improvement. A program was launched in February 1972 to inventory and recommend measures for restoration of many of these fields to a useful and productive condition. Cultivated fields are beneficial to wildlife, including both game and nongame species, particularly during years of natural food shortages and/or severe winters. The fields are also esthetically pleasing remnants of a past era.

Approximately 2300 acres are now administered under Agricultural Lease Permits for production of row crops (28%) and legume hays (72%). Fertilizer specifications, maintenance of border strips, cutting times, and various other conditions are attached to the permits to ensure that wildlife benefits will be realized.

In inventory phase of the program is completed, and long-range guidelines are now under review.

# # #

## PHOTO-SURVEILLANCE OF RIVER TRAFFIC

INVESTIGATOR: L. F. Marnell  
National Park Service

SUMMARY OF PROGRESS: Five custom-built 8 mm, time-lapse cameras were installed at 10 locations along the Current and Jacks rivers to record boat traffic operating inside the boundaries of Ozark National Scenic Riverways. The project was initiated on an experimental basis in 1972 and became operational along 120 miles of river this year. A full-time, seasonal technician was hired to carry out the field operation, and a work/study student performed the data analysis with a special step-motion projector. Approximately 310 rolls of film were taken during the 1973 floater season, which extended from the Memorial Day weekend thru Labor Day; the film equaled 3720 hours of observation based on 12-hour sample days. A general survey was conducted by park rangers on their daily boat patrols to provide supplemental information.

The project yielded information on the volume, composition, ownership, and distribution of river traffic. River use in 1973 was up from 15 to over 100% on various sections of river, with the major increase occurring on downstream portions. Although concessioner traffic was up slightly from the 1972 level, private and illegally operated (i.e., "bootleg") rental canoes constituted the largest share of the increase.

This information is needed to provide a basis for river-use planning at OZAR and to establish a reference base for annual monitoring. A more advanced automatic timer is

is under development to reduce driving mileage and night operations on the project, and a time-reference system is being experimented with to quantify the movement patterns of traffic operating on various sections of river.

# # #

## FLOATER IMPACTS ON RIVERWAYS ENVIRONMENTS

INVESTIGATOR: Carl D. Settergren  
University of Missouri

SUMMARY OF PROGRESS: Development of an ecologically sound river-use management plan at Ozark Riverways will require consideration of the nature and extent of changes occurring in the environment resulting from floater use. Objectives of this study are to (1) measure and document floater impacts in areas receiving moderate to heavy use; (2) identify unique areas and natural features that are particularly sensitive to physical abuse; (3) identify sites where resource deterioration has reached the critical stage; (4) evaluate prospects for restoration of severely modified environments and assess the capacity for natural rejuvenation during periods of nonuse; (6) recommend methods for protection and maintenance in areas receiving heavy use; and (7) recommend guidelines which will enable the National Park Service to continue monitoring floater impacts after completion of the study.

Field work was conducted from 1 July through 30 August and involved reconnaissance, selection of study sites, mapping, photo documentation, and cataloging of areas receiving floater impact. Preliminary findings indicate that vehicular activities attending canoe floating and other types of river-use are generating significant and destructive impacts. Pulltite Spring, Cave Spring, and other natural features have suffered extensive damage, and corrective measures will be necessary. Gravel bars appear to be relatively insensitive to floater use.

The study is to be continued through the 1974 floater season, during which time the emphasis will be toward quantitative measurement of impacts on selected sites.

# # #

## TROUT STOCKING IN THE UPPER CURRENT RIVER

INVESTIGATOR: Missouri Conservation Department

SUMMARY OF PROGRESS: During the past year the Missouri Conservation Department released approximately 1800 catchable-size rainbow trout into the Upper Current River at several points above Cedargrove. Plantings were made over a period of several months beginning in the early spring. As in most Missouri streams, trout do not reproduce in the Current River, thus, the program is a "put and take" proposition. Its purpose is to provide trout fishing for a minority group of Missouri sportsmen in a quasi-natural setting.

Trout for this program were raised up to about 10 inches in length at the Montauk State Fish Hatchery near the headwaters of the Current River. Production costs averaged about \$0.46 per pound of trout.

No major change in the stocking allotment is anticipated for 1974, unless the proposed

"fish for fun" program is implemented. This program, as presently envisioned, would allow anglers to keep one trout 16 inches or over in length per day. The program has been recommended by the National Park Service and the Missouri Conservation Department, but administrative complications have thus far prevented implementation.

# # #

## VISITOR PERCEPTIONS OF CROWDING ON THE OZARK NATIONAL SCENIC RIVERWAYS

INVESTIGATORS: Kenneth C. Chilman) Southern Illinois University  
James Habermehl ) University of Missouri

SUMMARY OF PROGRESS: During the past 5 years, floater activity on the Upper Current River has increased dramatically. The National Park Service has become justifiably concerned that ecological and sociological impacts accompanying such use-levels could undermine the purpose for which the riverways was created. A comprehensive river-use management plan which considers both environmental and sociological factors must be developed.

During the summer of 1972, 333 floaters were interviewed in a study designed to gather information about perceptions of crowding among people who float on different sections of the riverways. A follow-up mail questionnaire was sent out, and 307 (92%) were subsequently returned. Information gained from the survey resulted in a Master's thesis, a copy of which was submitted to the riverways in March 1973. The study indicated that a general "crowding" problem, in terms of visitor perceptions, does not exist; that is, a problem does not exist at all places on the river at all times during the floater season. Overall, 27% of the respondents did encounter more people than they desired, and 14% expressed strong dissatisfaction. Weekend respondents registered more negative responses than weekday floaters and the trend was most evident on the heavily used sections of the river. However, 98% of the respondents stated that they would return for another float. Negative experiences appear to occur mainly in fast water chutes where "bottleneck" situations often develop. Conflicts between different user groups (church groups, hippies, etc.) were also noted. It was found that canoeists tended to travel in groups, 41% in group sizes of 10-50 people, 23% with 5-8 people.

Recommendations were made for additional studies

# # #

## CAVE RESEARCH AT OZARK NATIONAL SCENIC RIVERWAYS

INVESTIGATOR: Cave Research Foundation

SUMMARY OF PROGRESS: National Park Service personnel from OZAR met on 3 September 1973 with members of the Cave Research Foundation (CRF) at Mammoth Cave, Kentucky, for discussions of cave resource problems at OZAR. The CRF is a nonprofit research organization whose members work voluntarily on projects in several states. The need for a cave inventory and better information about cave resources at OZAR was identified. Data of this kind are needed for resource protection and visitor safety. Preliminary arrangements were made for CRF involvement at OZAR.

A seven-man team of CRF members visited OZAR on 22-23 September for a preliminary reconnaissance of caves and springs along the upper Current River. A report of findings

from this initial survey was received 19 December and recommendations were made for further work. To date, no formal proposal or study plan has been prepared.

## PINNACLE NATIONAL MONUMENT

### GEOLOGY OF THE PINNACLES VOLCANIC FORMATION AND NEENACH VOLCANIC FORMATION AND THEIR BEARING ON THE SAN ANDREAS FAULT PROBLEM

INVESTIGATOR: Vincent Matthews  
University of Northern Colorado

SUMMARY OF PROGRESS: 1. Pinnacles Volcanic Formation correlates with Neenach Volcanic Formation.  
2. San Andreas fault has moved 195 miles in 23.5 million years.  
3. Chalowe Creek fault is probably early Miocene trace of San Andreas.  
4. Much, if not all, of Pinnacles volcanics were deposited subaqueously.  
5. Breccias were not deposited in their present dip on flanks of old volcano. They were tilted later.  
6. Chemistry of volcanic rocks is calc-alkaline.

RECOMMENDATIONS: Cretaceous granitic rocks in Pinnacles and Neenach should be studied for correlation.

## PLATT NATIONAL PARK

### A SURVEY OF THE NATURAL HISTORY OF PLATT NATIONAL PARK

INVESTIGATOR: Joseph B. Schiel, Jr.  
University of Oklahoma

SUMMARY OF PROGRESS: Manuscript is to be published by Oklahoma University Press. Research has been terminated over one year ago. See item 6 on report submitted 12-22-72.

## HYDROLOGY OF PLATT NATIONAL PARK, OKLAHOMA

INVESTIGATORS: Donald L. Hart, Jr.) USGS  
Garland Moore ) National Park Service

OBJECTIVES: Continuation of a study which was temporarily halted to determine if local ground-water withdrawals from areas adjacent to the park have any significant effect on Buffalo and Antelope springs discharges.

METHOD: University of Oklahoma contract.

RESULTS AND DISCUSSION: Two Stevens "F" type recorders were installed in observation wells drilled in 1972.  
Overall study has been temporarily stopped because of lack of funds.

CONCLUSIONS: None at this time - data being analyzed.

PLANS FOR 1974: Continue collection of basic ground-water level data in Observation Wells Nos. 1 and 2. Propose for reactivation of hydrological study of the park to objectives previously outlined with the University of Oklahoma doing the study.

### Bibliography:

Hydrology of Platt National Park Area, Murray County, Oklahoma by Donald L. Hart, Jr., U.S. Geological Survey 1972.

## POINT REYES NATIONAL SEASHORE

### RESTORATION OF TULE ELK PORE-N-7

INVESTIGATORS: Dale R. McCullough  
Richard M. Brown

OBJECTIVES:

1. Determine the carrying capacity of the habitat within the proposed enclosure.
2. Determine the number, ages, and sex ratios to be represented in the initial restoration of tule elk to the seashore.
3. Carry out extended monitoring of the vegetation before and after reintroduction of the tule elk.
4. Determine management problems that are likely to result from restoration of these animals to the seashore and provide alternative ways for resolving these problems.

METHODS: Identify appropriate study sites, both inside and outside the elk enclosure.  
Establish transects, plots, and exclosures on the selected study sites to determine pertinent relationships of the vegetation to the elk and associated ungulates, both native and exotic.

RESULTS AND DISCUSSION: Due to increasingly high cost estimates for the construction of an elk enclosure (and associated facilities) on the site selected in 1972 for restoration of tule elk to the seashore, alternative sites were considered again. As a result of the then recent acquisition of Tomales Point, this area became an available alternative, which was subsequently selected. Surrounded on its two long sides by the Pacific Ocean and Tomales Bay, respectively, this point is additionally bounded in large part by steep cliffs. Thus, the proposed enclosure of approximately 2600 acres will require only slightly more than 2 miles of fencing for the herd boundary--at a fraction of the cost for the former proposed site.

Dr. Dale R. McCullough, tule elk specialist, examined this area during 1973 and advised us in writing that it is highly suitable habitat for tule elk.

The death of Dr. Charles Hansen, a major consultant during the early stages of this project, has impaired the search for a principal investigator on this project and no likely candidates are immediately available.

PLANS FOR 1974: It has become evident that on-site implementation of this project must be supported by adequate treatment in the National Resources Management Plan now being directed toward the completion of this plan by or before 30 June 1974.

Continued efforts to obtain a principal investigator for the long-range conduct of this project.

Upon approval of the completed Natural Resources Management Plan, establish transects and plots on the restoration site to describe and monitor the vegetation, with the ultimate objective of determining the optimum carrying capacity of this total range for tule elk.

Reference:

McCullough, D. R. 1969. The tule elk: Its history, behavior, and ecology. University of California Press, Berkeley. 209 p.

# # #

PRESCRIBED BURNING, BISHOP PINE FOREST  
PORE-N-8

INVESTIGATORS: Laurie Lippitt  
Richard M. Brown  
Explorer Post 30, San Francisco

OBJECTIVES: 1. To determine, insofar as possible, the natural conditions and processes of bishop pine forest, especially with respect to fire.  
2. To determine the manner in which fire should be used as a management tool to help restore the natural conditions to this forest.

METHODS: Prepare a detailed, large-scale working base map of the proposed 3-4 acre site. Obtain pertinent data on environmental factors, including light, air temperature and humidity, slope, and soil conditions.

Determine major floristic and faunistic elements of the area, with emphasis on vascular plants and vertebrate animals. By means of quadrats and transects, determine species coverage by major plant species. Individually number all trees on the site that are 6 inches or more in diameter at breast height (dbh). For each of these trees, obtain data as to species, dbh, and general condition; by means of an increment borer, determine ages of selected trees.

Establish a fire weather station to obtain input data required for the prescribed-burn formula. Establish in the site vicinity a control area having conditions as similar to the burn site as possible.

**RESULTS AND DISCUSSIONS:** Data were obtained at the site on light, air temperature and humidity, soil horizons, soil pH, soil texture, floristic composition, tree ages, germination success, and seedling survival. Fourteen randomly located meter-square plots were established, and percentage cover by species was obtained. All trees 6 inches or more dbh were individually number-tagged for referencing various data to them; a total of 373 such trees, representing three species, were found. Increment borings of selected trees gave an age range from 21 to 39 years.

A fire weather station was established on the site early in 1973, and preliminary data were obtained for deriving the prescribed-burn formula. Subsequently, as a result of vandalism, this station was destroyed; its replacement has been obtained and will be placed on site early in 1974.

A comparable control site has been selected; it is located immediately across the roadbed serving as a firebreak (boundary) for the burn area.

As a result of an inquiry to the park, Explorer Post 30, sponsored by the Bechtel Corporation, San Francisco, has taken on as special projects two aspects of this overall study. The post personnel were oriented to the study and the site late in 1973. Under the direction of Bechtel engineers, the post personnel will prepare a large-scale map of the project site. In addition, under the supervision of park personnel, they will perform on-site determination of the mammalian fauna and some aspects of its population structure.

Reexamination of a 1070 burn site within bishop pine forest in the adjacent Tomales Bay State Park suggests that, after 3.5 years, the percentage cover by Australian burnweed (*Erechtites prenanthoides*) has begun to decline. On the other hand, only one post-1970 bishop pine seedling has been found on the entire burn site of approximately 9 acres. This raises the question of whether the reproductive failure of bishop pine thus far may be due to inadequate nutrient recycling of the pre-burn stand of trees or perhaps some other factor, rather than the direct effect of prompt encroachment by burnweed and exotic grasses.

Review of information obtained to date suggests that conditions in this stand at the present time approximate closely those of the bishop pine forest at times of natural burning. The scant literature on fire periodicity in this forest type suggests the occurrence of fires about every 25-30 years, on the average. Thus, existing fuel accumulation probably now approximates the usual amount on the ground at the time of a normal burn. Abundant even-aged stands of bishop pine on the seashore indicate further that fires here in the past were of high heat intensity and achieved essentially 100% destruction of existing stands, accompanied by rapid nutrient recycling and subsequent germination of a replacement stand of bishop pines.

**PLANS FOR 1974:** Complete the preparation of the Natural Resources Management Plan for the seashore by the established target date of 30 June 1974; this document to serve as the basis for implementation of the initial prescribed burn at the selected site. Upon approval of this document, proceed with the burn itself whenever total conditions are favorable for doing so; this includes meeting the requirements of the burn formula and the conditions set by the local Air Pollution Control District.

Complete the preparation of the large-scale base map of the burn area early in the year.

Replace the fire weather station on the burn site; obtain all data needed for preparation of the burn formula.

Obtain additional biological data for the area, with emphasis on the vertebrate species present and the population structure of the mammalian species.

References:

- Griffin, J. R., and W. B. Critchfield. 1972. The distribution of forest trees in California. USDA Forest Service Research Paper PSW-82/1972. Berkeley, California, Pacific Southwest Forest and Range Experiment Station. 114 p.
- Kuchler, A. W. 1964. Potential natural vegetation of the conterminous United States American Geographical Society, Spec. Publ. No. 36. 39 p.

# # #

ECOLOGICAL WILDLIFE STUDY, DEER  
PORE-N-11

INVESTIGATOR: Oscar Brunetti  
California Department of Fish and Game

SUMMARY OF MONTHLY collections of both species of exotic deer, axis and fallow, were  
PROGRESS: begun on the seashore in October 1973. With the objective of obtaining  
approximately 5 deer, any sex and age, of each species each month, a  
total of 32 deer were taken through December 1973.

These deer were submitted to the California Department of Fish and Game's Sacramento laboratory for examination by Oscar Brunetti and staff. Results are to be provided to the seashore on a quarterly basis, at the end of the quarter immediately following the one in which the animals were taken. Thus, the first report should be received by the end of March 1974.

Current plans are to continue this project for at least one full year, through September 1974. If a need becomes evident, it will be continued for a second year, through September 1975.

# # #

EFFECT OF TILLAGE ON DISEASES OF NATIVE PLANTS

INVESTIGATOR: C. E. Yarwood  
University of California

SUMMARY OF This year was mainly a continuation of trials which have been underway  
PROGRESS: for about 10 years. Results were mainly a confirmation of previous  
results. All plants in the plot except *Echinocystis fabacea* were favored  
by tillage. The following infections were especially favored by tillage in 1973:

*Erysiphe cichoracearum* on *Baccharis pilularis*;  
*Puccinia evadems* on *Baccharis pilularis*;  
*Phoma pavia* on *Aesculus californica*;  
*Taphrina aesculi* on *Aesculus californica*; and  
*Erysiphe cichoracearum* on *Aster Chilense*.

*Puccinia cirsii* was observed on *Cirsium lanceolatum* in the plot for the first time in 1973 and was favored by tillage.

It seems likely that nothing basically new beyond that already published is likely to result unless new methods are used. I would like to see if continuation of vegetative growth into the late rain-free summer by irrigation would yield results of interest.

# # #

## FOOD HABITS OF MARINE MAMMALS OF CALIFORNIA

INVESTIGATOR: Robert E. Jones  
University of California

SUMMARY OF PROGRESS: The food data information from seashore animals are included in my Master's thesis submitted to Humboldt State University at Arcata. All food items recovered will be deposited with U.S. Department of Commerce, NOAA Marine Mammal Division, Seattle, Washington. Skulls will be retained here at Berkeley.

I wish to continue to respond to all calls on marine mammals, this resource (dead animals) has not been utilized and valuable information on dietary habits has been salvaged. All reports are investigated.

In addition, National Park Service specimens have been cleaned by personnel at the Museum of Vertebrate Zoology. We will continue to give aid in enlargement of Point Reyes scientific collection and preparation, if requested by NPS employees.

# # #

## AN ANALYSIS OF THE ARTHROPODS OF POINT REYES NATIONAL SEASHORE AND THEIR INSECT-PLANT INTERRELATIONSHIPS

INVESTIGATORS: E. I. Schlinger)  
Peter A. Rauch ) University of California

SUMMARY OF PROGRESS: Progress is slow, but sustained.

SIGNIFICANT FINDINGS: To date we have amassed an ecological-oriented collection of about 4000 specimens of insects, spiders, and mites, mostly from the fragile dune area. Each specimen's complete ecological data are recorded in such a way that all specimen data are computerized. We do not have the proper funding at present to program these complicated data bases, so data have been partially key-punched and stored on computer tapes.

RECOMMENDATIONS: If proper funding becomes available, all insect-plant data and specimens can be made available to the park headquarters and be used in a variety of ways, i.e., taxonomic, plant hosts, predators, parasites, ecological niche, diversity, uniqueness, etc.

It is our hope that some agency could combine money with our effort to satisfactorily complete this research project within the next 5-10 years.

## BREEDING-BIRD CENSUSES

INVESTIGATOR: Robert M. Stewart  
Point Reyes Bird Observatory

SUMMARY OF  
PROGRESS: In spring 1973, PRBO continued censuses of breeding land-birds at eight selected sites on Point Reyes National Seashore. These censuses will be published in detail in *American Birds*.

A summary of the 1973 censuses and a comparison of these with the 1972 censuses appear in the *Point Reyes Bird Observatory Newsletter*, No. 27:6-7.

The eight sites censused included two each of disturbed coastal scrub, mature Douglas-fir, logged Douglas-fir replanted to Monterey pine, and oak-bay mixed forest.

Of 20 common species censuses in spring 1973, in comparison with 1972, 16 declined in numbers, 3 increased, and 1 stayed the same. The only resident species that apparently held their own were the Wrentit, Winter Wren, and Hutton's Vireo.

# # #

## STUDIES ON THE POPULATION BIOLOGY OF THE CLADOCERAN GENUS, *DAPHNIA*

INVESTIGATOR: Lester W. Lee  
University of California

SUMMARY OF  
PROGRESS: Population of *Daphnia pulex* in Bass Lake has been studied in field and in laboratory. I am currently in the process of completing laboratory studies concerning the genetics and evolutionary significance of an eye-size polymorphism found in this population. I am also studying the effects of certain factors such as O<sub>2</sub> concentrations, population density, and temperature in controlling the reproductive cycle of *D. pulex*.

# # #

## THE ROLE OF SONG DIALECTS IN WHITE-CROWNED SPARROWS

INVESTIGATOR: Myron Charles Baker  
The Rockefeller University

SUMMARY OF  
PROGRESS: Samples of White-crowns collected for genetic analysis in the summers of 1972-73 have been completed. The results indicate that song dialects represent panmictic units within which genes are freely exchanged. Restriction in gene flow between dialects is apparent. These results are leading to other areas of research. I banded juvenile White-crowns in the vicinity of a dialect boundary in the summer of 1973 to determine if dispersal patterns of the young are affected by the song differences. This will continue in the summer of 1974. In addition, I hope to trap live a few naive females to test for song preferences in a laboratory experiment. This work will occur in the summer of 1974 also.

The results from the genetic analysis are presently being written up for publication in *Evolution*. This publication should be ready sometime in the next few months.

# # #

#### A FIELD SURVEY OF THE EXOTIC AXIS DEER AT POINT REYES NATIONAL SEASHORE

INVESTIGATOR: Henry W. Elliott III  
The University of California, Davis

SUMMARY OF A summary of the most pertinent findings of the completed field work  
PROGRESS: reported in my Masters thesis is as follows: Approximately 400 axis deer  
inhabited Point Reyes Peninsula in October 1973. A 22% estimated yearly  
increase of the female population will result in continued increase and expansion of  
axis deer throughout the pastures grazed by cattle. Competition lowers the carrying  
capacity for cattle but it is probably not affecting the axis deer.

Direct observation of the population dynamics of the axis deer and the entire ungulate  
population's impact on the range should be a continuous project. The information should  
be integrated with the results of the current scientific collection to justify any  
management policy that stipulates limitation of the population at prescribed level. The  
determination of this level will be influenced by aesthetic, biological, and political  
considerations.

# # #

#### SOME ASPECTS OF THE NATURAL HISTORY AND ECOLOGY OF FALLOW DEER ON POINT REYES PENINSULA

INVESTIGATOR: John D. Wehausen  
University of California, Davis

SUMMARY OF See Master's thesis of J. D. Wehausen - Some aspects of the natural  
PROGRESS: history and ecology of fallow deer on Point Reyes Peninsula.

# # #

#### X-RAY ANALYSIS OF SEDIMENTARY ROCKS, DRAKES BAY

INVESTIGATOR: Thomas E. Ronan, Jr.  
University of California, Davis

SUMMARY OF Rocks collected from the talus slopes and cliffs of Drakes Bay were  
PROGRESS: analyzed through the use of x-ray radiography. Samples which appeared  
to contain burrows of an extinct crustacean (*Ophiomorpha*) were sectioned  
on a geologic saw and x-rayed using an industrial metallurgical x-ray machine.

Examination of the printed x-rays revealed incomplete or a complete lack of internal  
biogenic sedimentary structures.

This leads me to the conclusion that either my sampling was inadequate, i.e., the rocks were mostly from between bedding planes and therefore lacking intense biologic activity, or the rocks, in spite of surface traces, are without internal biogenic structures.

I would like, someday, to resample the locality as a means of confirming my previous results. However, I cannot predict the undertaking of such work in the near future.

# # #

#### PREDICTIVE SYSTEMATICS OF NATURAL POPULATIONS

INVESTIGATORS: Richard J. Johnston  
William Klitz

SUMMARY OF PROGRESS: The work done in the Point Reyes National Seashore was sampling of House Sparrow (*Passer domesticus*) populations at the tip of the peninsula. We caught 160 individuals and saved their skeletons, kidneys, spleens, livers, and blood. We looked for electrophoretically demonstrable enzyme phenotypes in the tissues. We found that the sample had normal kidney esterase characteristics and normal blood serum transferring characteristics, judged by other sparrow samples from Kansas. We are measuring the dimensions of bones from the skeletons and this is about half done; no biometric studies of the dimensions have been undertaken at this time.

# # #

#### MARIN HERONRY STUDY

INVESTIGATORS: Helen M. Pratt) Point Reyes Bird Observatory  
Dale Elliott )

SUMMARY OF PROGRESS: The purpose of the project is to compare population levels and reproductive success of Great Blue Herons in the various active Marin County heronries. Two of the five known heronries in Marin County lie within the boundaries of Point Reyes National Seashore; one of these was not active in 1973 but was known to be active in 1972. This inactive heronry is located about a mile from headquarters and it contained from 19 to 24 active nests in 1972. I believe it to be an old heronry that may well become active again. The other seashore heronry is on Schooner Bay behind the Johnson Oyster Co. It contained 15 active nests in 1973. Other active Marin County Great Blue Heron colonies in 1973 were at Stafford Lake, (5 nests), near Nick's Cove (10 nests), and at Audubon Canyon Ranch (58 nests). We propose to visit these heronries at regular intervals, not less than once every 2 weeks, locate the active nests, and follow their progress till they are abandoned. This project is contingent on availability of gasoline. If rationing is put into effect, the project may have to be curtailed.

## GENETIC SIMILARITY BETWEEN RACES OF GASTEROSTEUS

INVESTIGATOR: John C. Avise  
University of California, Davis

SUMMARY OF PROGRESS: The collection made in Point Reye has been compared with other fresh-water and marine forms of *Sarterosteus* in allelic composition at approximately 14 loci encoding enzymes. The overall biochemical similarity is high, in striking contrast to the distinctness of the plate morphology. The high biochemical similarity precludes the use of allozymes in determining patterns of hybridization between the races.

# # #

## FIELD STUDIES OF BEACH PSEUDOSCORPIONS OF POINT REYES (ARACHNIDA: PSEUDOSCORPIONIDA)

INVESTIGATOR: Vincent F. Lee  
California Academy of Science

SUMMARY OF PROGRESS: As of the end of 1973, I have made four visits to the various beaches of the Point Reyes National Seashore. These were exploratory trips to check for beaches which potentially could have populations of *Garypus californicus* Banks and *Halobisium occidentale* Beier. So far, I have found only one specimen of *G. californicus* on the beach at the end of the Bear Valley Road. I have not found any pseudoscorpions near the Point Reyes lighthouse, along selected points of Tomales Bay, near Abbotts Lagoon, etc. These pseudoscorpions are highly habitat restricted, and any disturbance of their habitats (usually under rocks, driftwood, and other littoral debris) usually means displacement or even reduction in the population size. I have noticed this on beaches south of Point Reyes. I have made general biological observations on nest construction, feeding behavior, grooming, morphology, and brooding behavior in the laboratory on specimens collected outside the seashore. *Halobisium occidentale* are generally found in rock crevices in the littoral zone, but I have found them under rocks in the Bolinas Lagoon. I have not made any concerted effort to locate them at Point Reyes.

For the future, field work will not begin until early in the spring. I hope to make more field trips to the beaches to locate a suitable one that is not strongly influenced by human pressures.

# # #

## DISTRIBUTION AND BIOLOGY OF INTERTIDAL INSECTS, INCLUDING ALGAL ASSOCIATIONS

INVESTIGATOR: Raymond L. Peterson  
California State University

SUMMARY OF PROGRESS: Progress at Point Reyes is virtually nil; one collecting trip as of today.

SIGNIFICANT FINDINGS: New distributional record for *Aphrosylus nigripennis* (Diptera: Dolichopodidae), heretofore not known to be south of Alaska according to the literature.

If I can complete my work at the PRNS within 5 years, it will be a minor miracle; however, I'd like the opportunity to continue.

# # #

### ENTOMOLOGY 230, BIOLOGY OF PARASITOIDS

INVESTIGATOR: Leopoldo E. Caltagirone  
University of California

SUMMARY OF PROGRESS: Galls induced by the cocidomyid fly (*Rhopalomyia californica* Felt) on coyote brush (*Baccharis pilularis* DeCandolle) were collected by the nine students taking the course of Biology of Parasitoids, Ent. 230, on 15 November 1973, in the vicinity of the Point Reyes Bird Observatory, Point Reyes National Seashore. The galls--some 30 per student--were taken to the laboratory. Some of them were dissected and the gall inhabitants observed, and some were placed individually in vials to allow the inhabitants to develop and emerge. The purpose of this exercise was to acquaint the students with the interrelations between plant (coyote brush), cocidomyid, and the various other gall inhabitants (parasites and inquilines).

The following species of insects were obtained:

*Rhopalomyia californica* Felt (Diptera, Cecidomyiidae)--induces terminal galls on coyote brush.  
*Platygaster* sp. (Hymenoptera Platygasteridae)--internal parasite on larvae of *R. californica*.  
*Torymus* sp. (Hymenoptera Torymidae)--ecto parasitic on larvae and pupae of *R. californica*.  
*Tetrastichus* sp. (Hymenoptera, Eulophidae)--relationship not determined.  
An undetermined Pteromalidae (Hymenoptera)--relationship not determined.

In all probability another group of students will repeat this exercise in November 1974 if permission is obtained from the Point Reyes National Seashore.

# # #

### BIOLOGY OF BATS AT POINT REYES NATIONAL SEASHORE

INVESTIGATOR: James L. Patton  
University of California

SUMMARY OF PROGRESS: A total of 184 individual specimens representing 6 species of bats (1 *Eptesicus fuscus*, 77 *Myotis yumanensis*, 47 *Myotis thysanodes*, 13 *Myotis californicus*, 4 *Antrozous pallidus*, and 20 *Tadarida brasiliensis*) were collected from buildings at three general areas of Point Reyes National Seashore (Point Reyes Bird Observatory, the National Seashore Headquarters, and Muddy Hollow) beginning 29 August 1973 (see below). These localities have been rechecked at approximately 1-month intervals to date.

The purposes of the current study include the following: (1) to ascertain

the reproductive cycles of the species present; (2) to determine differential use of roosts on a temporal basis by species, by sex composition, or by age classes; and (3) to determine the overwintering activity patterns of those species encountered. We currently know next to nothing about the general natural history of these bats in central portions of coastal California, as colonies of bats which can be worked on a temporal basis are quite rare. It is particularly fortunate, therefore, to have had the opportunity to continually examine those colonies at Point Reyes.

We anticipate that the project as currently outlined will be of a long-term nature because periodic checks (at approximately monthly intervals) are required to understand the questions given above. Moreover, we have discussed bat control measures with several staff members of the park, and we feel that it is desirable to gather baseline data on existing populations before eradication or other control measures are developed fully.

Date of collection	Number per species					
	<i>E. fuscus</i>	<i>M. yuman.</i>	<i>M. thysan.</i>	<i>M. calif.</i>	<i>Antro.</i>	<i>Tad.</i>
29 August 1973	-	33	1	-	-	9
2 September 1973	1	-	-	11	-	-
5 September 1973	-	31	-	-	-	11
12 October 1973	-	-	1	2	-	12
30 October 1973	-	12	34	-	3	-
27 November 1973	-	1	11	-	1	-

# # #

#### A REVIEW OF THE POPULATION STUDIES OF MARINE LIFE, POINT REYES NATIONAL SEASHORE PARK

INVESTIGATOR: Gordon L. Chan  
College of Marin

SIGNIFICANT FINDINGS: Three areas of review were initiated July-August 1973, at Double Point, Split Rock Cove, and Bird Rock:

- (1) At Double Point, all invertebrate species from population studies of July 1970 were observed, along with an additional nine new species for the area. All population densities observed were stable except for a 30% reduction in the density of the California sea mussel (*Mytilus californianus*).
- (2) At Split Rock Cove, 11 new species were recorded for the area. All population densities observed were stable.
- (3) At Bird Rock, 26 new species were recorded for the area. All species densities observed were stable, except for a drastic reduction in the red abalone (*Haliotis rufescens*) tagged population. No tagged abalones of 1969-70 were observed, and the subtidal beds of these mollusks were estimated to have been reduced by 50-60% as compared to the density observed in surveys during 1969-70. Probable cause of abalone reduction at this area may be attributed to human predation.

## SURVEY OF TIDEPPOOL FISHES IN POINT REYES NATIONAL SEASHORE

INVESTIGATOR: Martin R. Brittan  
California State University, Sacramento

SUMMARY OF PROGRESS: The project is to survey the basic intertidal habitats in Point Reyes National Seashore with the purpose of identifying and establishing the relative numbers of the fish species present. No collections have been made within the seashore as yet, primarily because of adverse weather conditions and logistics resulting from the gasoline shortage; these, we think, can be circumvented. Duplicate collections will be deposited at the seashore, and we intend to cooperate in supplying information on which exhibits may be based, etc. A recent collection was made at Duxbury Reef (Agate Beach) and specimens and a copy of the field data sheet will be sent to the seashore (this reef is similar to others in the south section of the seashore).

# # #

## DESCRIPTION OF THE TERRESTRIAL ENVIRONMENT, POINT REYES NATIONAL SEASHORE

INVESTIGATORS: Harold Biswell) University of California  
James K. Agee )  
Eric B. Janes ) Denver Service Center

SUMMARY OF PROGRESS: The purpose of the study was to assemble and synthesize (within the attached framework) RBI information and to prepare it in a narrative for an upcoming environmental statement. The completion report is well illustrated. Copies are on file at the park, region, and Denver Service Center.

## REDWOOD NATIONAL PARK

### SOCIOECONOMIC IMPACT DATA FOR THE REDWOOD NATIONAL PARK

INVESTIGATORS: Henry Vaux ) University of California  
Eric B. Janes) Denver Service Center

SUMMARY OF PROGRESS: The study collects available economic and related data and analyzes it in an effort to provide the background essential for assessing the economic and social impact of the Redwood National Park and the Master Plan for its development and management. In varying degrees and ways the park is potentially significant to the people of the Pacific Coast states, to the people of the subregion in which the park is located, and to the people of the communities in the area immediately adjacent to the park boundaries. As park impacts will vary greatly in both

magnitude and variety, depending upon which of these groups of people is taken as the point of reference, the study attempts to analyze impacts in each of these three reference frames.

# # #

### ECOLOGY OF THE COAST REDWOOD REDW-N-1

INVESTIGATOR: Stephen D. Veirs, Jr.

OBJECTIVES: (1) To acquire information leading to an understanding of the basic ecological status of the coast redwood (*Sequoia sempervirens*) vegetation; (2) to determine the role of fire within the vegetation type; and (3) to prescribe long-term management for the vegetation of the park, if needed, in order to maintain the native vegetation in its natural condition.

METHODS: Age and size distribution for all trees and other woody vegetation on representative hectare plots outside the park which are being commercially harvested. Occurrence and frequency of fire are determined from stumps.

RESULTS AND DISCUSSION: Little progress in this work has been achieved during 1973 due to the press of other work and to difficulties encountered in locating suitable field study areas.

PLANS FOR 1974: Three or four additional study plots will be worked up during 1974 which should include the bulk of the field work necessary for a first good look at the basic ecological status of redwood.

# # #

### SUCCESSION ON CUTOVER LAND WITHIN REDWOOD NATIONAL PARK REDW-N-3

INVESTIGATOR: Stephen D. Viers, Jr.

OBJECTIVES: More than 11,000 acres of forested land in the Federal holdings of Redwood National Park were clearcut, selectively logged, or otherwise commercially harvested prior to the establishment of the park in 1968. The vegetation now established on these disturbed lands includes native and exotic tree reproduction and other native and exotic species. With this research we will attempt to characterize this secondary vegetation by sampling representative areas and predicting short- and long-term prospects for the reestablishment of the native forest vegetation. Recommendations for management designed to speed this recovery will be presented.

METHODS: Forty-one line and strip transects have been established on recently cut-overlands throughout Federal portions of the park. These provide data on species composition, cover, and relative status for the vegetation found on these lands.

RESULTS AND DISCUSSION: The data await additional manipulation prior to reporting of results. Preliminary inspection of the data suggests that large numbers of trees have become established since logging and generally that larger numbers of seedlings are found on more disturbed sites, while trees established on less disturbed

sites grow more rapidly. The rate of growth in height, in the open, by Douglas-fir, Sitka spruce, and alder exceeds that of the redwood. Best seedling redwood growth is obtained where some shading occurs. Browsing, especially by elk, of redwood and Douglas-fir is locally heavy.

PLANS FOR 1974: The data obtained in the study to date will be subjected to analysis and prepared for publication. Additional sampling of older cutover on nonpark lands may be necessary to describe variations in successional patterns resulting from the increased recent use of artificial methods of reestablishing forest vegetation on harvested lands.

# # #

## STREAM SYSTEM STUDY REDW-N-11

INVESTIGATOR: Richard W. Janda  
U.S. Geological Survey

OBJECTIVES: To provide a basic understanding of the geomorphology and hydrology of the stream systems which are a part of, or influence, the natural resources of Redwood National Park and to develop an understanding of the influence of recent alteration of these systems through road building and commercial forest harvesting. The results of this research will be used to assist the park in the management of its natural resources and in the maintenance of the natural values for which the park was established.

METHODS: The 3-year study was begun in the fall of 1973 with the installation of stream sampling stations at seven sites in addition to two existing standard U.S. Geological Survey stream gaging stations on Redwood Creek (Humboldt County, California) and its tributaries. A third was installed on Mill Creek (Del Norte County, California). The sampling sites were selected to permit the sampling of streams draining forest lands which are undisturbed, currently being harvested, or recently harvested on similar geological parent materials. Water quality data are obtained at these and other sampling points synoptically during four selected storm events during the rainy season and at other times. Parameters measured include discharge, temperature, specific conductance, dissolved oxygen, pH, suspended sediment, bedload, dissolved and particulate carbon, complete water chemistry, and others. Other work within the watershed includes determination of stream cross sections (30 monumented level lines), identification of landslides and other unstable areas (23 surveyed stake lines in 6 areas), and analysis of changing stream configuration through the preparation of detailed channel maps.

RESULTS AND DISCUSSION: During 1973, all equipment was installed at 8 synoptic and 20 nonsynoptic sampling sites. One synoptic sampling was completed (a second one was accomplished in mid-January and two more will be completed as the rainy season progresses). Data collected to date do not permit interpretation, however, soil creep at rates of up to 5 ft/month have been observed on unstable prairies within the basin, and scour and fill in excess of 5 ft in Redwood Creek and 3 ft in its tributaries were observed this fall.

PLANS FOR 1974: During the remainder of FY 1974, additional stream sampling, both synoptic and nonsynoptic, will occur. As data become available, planning for the second sampling season will be accomplished.

### References:

Environmental surveillance for Redwood Creek. The study plan. 20 August 1973. Redwood National Park Typescript. 24 p. 1 map.

Colman, S. M. 1973. The history of mass movement processes in the Redwood Creek basin, Humboldt County, California. Unpublished thesis, Pennsylvania State University. 180 p. 4 plates.

# # #

#### RECENT HISTORY OF MASS MOVEMENT IN THE REDWOOD CREEK BASIN

INVESTIGATOR: Steve Colman  
U.S. Geological Survey

SUMMARY OF PROGRESS: Sequential aerial photography of the Redwood Creek Basin, with ground inspection, was used to determine the recent occurrence of natural and man-influenced mass movement within the Redwood Creek Basin, an area of high natural rates of erosion. Although commercial forest harvest and road building were contributory, these were not quantitatively separated from natural erosion, especially that resulting from extreme rainfall and flood events. A landslide map and strip map of the basin and the stream channel were prepared. A Master's thesis, Recent history of mass movement in the Redwood Creek basin, Penn State University, 1973, was completed and accepted.

# # #

#### THE IMPACT OF CLEARCUT LOGGING ON THE REESTABLISHMENT OF THE NORTH COASTAL REDWOOD FOREST PLANT COMMUNITY

INVESTIGATOR: Cynthia M. DiGiovanni  
University of California, Davis

SUMMARY OF PROGRESS: Present vegetation found on 180 acres of coastal redwood forest, clearcut 5 and 10 years before, was compared with adjacent uncut vegetation. A largely exotic flora is found on the clearcut area with Douglas-fir, not redwood, now the most successful tree species.

A thesis, The impact of clearcut logging on the reestablishment of the north coastal redwood forest plant community, December 1973, was prepared.

# # #

#### TREE SPECIES COMPETITION IN THE REDWOOD FOREST

INVESTIGATOR: Craig Lorimer  
Duke University

SUMMARY OF PROGRESS: Tree seedlings of redwood, Douglas-fir, western hemlock, and tanoak were obtained from native sources and placed in culture under controlled environmental conditions. Initial anatomical studies have been completed which demonstrate the occurrence of morphological differentiation in response to variation

in light intensities. Comparative studies of photosynthesis and respiration rates remain to be conducted.

## ROCKY MOUNTAIN NATIONAL PARK

### UNGULATE WINTER HABITAT CONDITIONS AND MANAGEMENT ROMO-N-08a and ROMO-N-12

INVESTIGATOR: David R. Stevens

OBJECTIVES: Determine condition and trend of winter habitats; determine departure from natural succession as affected by ungulate populations and relationships to the activities of man; formulate management objectives and criteria for ungulate populations.

METHODS: Twenty-six browse transects were measured in April and May on the key winter range for form class, decadence, and percent leaders used on 25-40 tagged plants.

Vegetation in 17 agronomy cages was clipped and weighed for comparison with similar samples from outside the cage to determine the percent of available forage utilized.

Pellet groups for both elk and deer were sampled on 10 replicas of 100 sp. ft. plots to determine relative use between species and years on each of the range transects.

Each transect was photographed.

Twenty-one transects on grassland and low shrub vegetation types established in 1968 were remeasured. Canopy cover was determined by estimating cover in 2 x 5 dm. plots. Line intercept of shrub and bunchgrasses were also measured.

Four aspen stands were measured by the point-center-quarter technique to determine tree and resprout density.

On five willow transects the plant intercept was measured on a 200 ft line.

All results were compared to identical measures made in 1968.

RESULTS: *East Slope:* Mill Creek continues to receive heavy elk use each year but deer use has been declining. As such, the forage used almost exclusively by deer has improved over the past 5 years. Bitterbrush (*Purshia tridentata*) condition, with a 47% decrease in utilization from 1968 and a 58% decrease in days use per acre from 1970, is improving (Table 1). Cover, as determined by canopy coverage measurement (Table 5), increased from 16% to 29%. The number of plants in a hedged condition decreased from 64% to 18%. Big Sagebrush (*Artemisin tridentata*) increased on one transect but decreased on another--the decrease, however, not considered a result of browsing. Green rabbitbrush also increased on one transect.

Elk use of the area has remained fairly constant over the 5 years, with days use per acre averaging 33 in 1969 and 34 in 1973. However, canopy cover of the native bunchgrass, mountain muhly (*Muhlenbergia montana*), declined on two transects. Carex increased on two

transects but decreased on one. Cheatgrass decreased considerably on the Mill Creek transect, which is a good indication of range improvement. Other grass species remained fairly stable. Willow (*Salix* spp.) declined in cover 9% on the Hallowell Park transect.

The Big Thompson drainage provides key range for both deer and elk. Two browse transects are located on the north moraine. These transects indicate days use per acre have remained stable over the 5 years but utilization on bitterbrush declined 41%. The ground cover of bitterbrush (Table 5) increased accordingly from an average of 12%-22%. In Moraine Park, over the 5-year period, the use by elk of the open meadow area has steadily increased from 32 days use per acre in 1969 to 83 in 1973 (Table 3). Percent utilization of meadow vegetation increased from 16% to 61%. Grassland areas, however, were not able to show the large increase in use. Condition of upland grass sites remained stable, but bare ground measurements appeared to decrease. The aspen site (Table 8) showed some improvement from 973 plants per acre to 1094, although utilization remained very high at around 80% for the 5-year period. Willow sites with even higher use of near 90%, however, did show some deterioration. Total willow cover, as determined by 200-ft line intercept, declined 14% on the upper site and 35% on the lower (Table 9). Willow at the lower site does not provide a substantial food source at present, and the site is destined to become a (*Calamagrostis canadensis*/*Carex aquatilis*) meadow within a fairly short time.

The Beaver Brook drainage includes the Beaver Meadows complex, Buck Creek, and the headquarters area. Deer use had declined for several years but was back up, except on the sagebrush transects, in 1973 as shown by both plant utilization and the number of days use per acre (Table 3). The cover of bitterbrush on three transects increased from 16 to 22% (Table 5). Big sagebrush cover did not increase much. The elk use in this area continued to increase primarily on the bitterbrush sites and the meadow areas. Days use per acre went from 18 to 39 on bitterbrush and 33 to 60 on the meadows. Percent utilization did not increase proportionally. The aspen sites showed considerable loss of vitality in that young plants were reduced on the upper site from 550 per acre to 289 and on the lower site from 2117 to 1778. Utilization remained high at 80%. Although willow use also remained very high--near 90%--as it has been for the last 3 years, the willow cover in Upper Beaver Meadows did increase on the transect 39%.

In the Fall River drainage, deer use the moraine along the north side. Heavy use continued as indicated by days use per acre of 27 and utilization on bitterbrush plants of 80% (Table 4). For the 5-year period, however, the bitterbrush cover increased slightly, as did green rabbitbrush. Mountain muhly also increased on the site. Elk use on the moraine decreased over the 5 years but remained high on the grass and meadow areas. Forage use was 55% and 51% of grassland and meadow areas, respectively. Over the past 5 years the vegetation on the xeric grass site remained almost unchanged. Oatgrass (*Danthonia parryi*) and needle-and thread (*Stipa comata*) increased, but Junegrass (*Koeleria cristata*) and mountain muhly decreased slightly in cover.

On the aspen transect, utilization in days use per acre dropped off this year but plant density has still declined from 1191 young plants and resprouts per acre to 959. More significantly, the mature trees declined from 87 per acre to 53. The lower willow transect which has received 80-90% use every year, however, still increased in willow cover by 16%.

Looking at the overall east slope range, bitterbrush has increased statistically on the shrub types by almost 50%. Most other key species, including mountain muhly and needle-and-thread, remained almost stable, with no statistically measurable changes. Bare ground decreased on 14 out of 21 sites, but also not statistically. Cheatgrass decreased on three out of six transects. These data would indicate a general improvement of the upland sites which include Ponderosa pine/shrub, grass/shrub, and grassland types.

In the aspen type, the stands have to be considered individually. In Moraine Park the density per acre of young plants actually increased. In Lower Beaver Meadows the density increased, but this was compensated by an increase in density of mature trees which would indicate just maturation of the stand or no deterioration. In Upper Beaver Meadows and in Horseshoe the loss of young plants per acre was also accompanied by a loss in mature trees. These two stands are undoubtedly deteriorating in condition and in time will disappear.

Willow decreased on three of the five stands measured. Undoubtedly this would indicate some deterioration but, except on the lower Moraine Park stand, it did not seem serious. In Hallowell, willow density is more dependent on beaver activity than elk.

PLANS FOR 1974: Annual pellet group counts, clipping measurements, and browse utilization measurements will be continued in April.

RECOMMENDATIONS: Based on the changes in plant cover as indicated by the 5-year measurements of 30 transects, no accelerated succession is indicated as a result of ungulate grazing. It is recommended that ungulate populations and range conditions trend continue to be closely monitored. Any change in this pattern should be documented.

No active population management is indicated by this data to be warranted within the National Park boundaries at this time.

Table 1. Forage Utilization and Range Use on Mill Creek

Species	Year	Trans.	% Hedged	% Decadent	% Util.	Days use/acre	
						Elk	Deer
Putr	1968	2	64	75	57	-	-
	1969	2	62	76	39	40	-
	1970	2	78	42	58	40	64
	1971	2	58	32	59	30	54
	1972	2	30	54	12	28	27
	1973	2	18	58	30	32	27
Artr	1968	1	48	76	31	-	-
	1969	1	40	76	39	20	40
	1970	1	72	56	23	17	30
	1971	1	35	35	43	30	40
	1972	1	52	52	15	10	13
	1973	1	92	92	17	34	20
Salix	1968	1	52	32	80	-	-
	1969	1	52	32	81	-	-
	1970	1	40	72	80	-	-
	1971	1	32	32	81	-	-
	1972	1	48	64	84	-	-
	1973	1	12	32	66	-	-
Grass	1969	1			-	33	47
	1970	1			70	54	50
	1971	2			66	64	10
	1972	2			65	38	27
	1973	2			82	36	30

Table 2. Forage Utilization and Range Use on Big Thompson (Moraine Park)

<u>Species</u>	<u>Year</u>	<u>Trans.</u>	<u>% Hedged</u>	<u>% Decadent</u>	<u>% Util.</u>	<u>Days use/acre</u>	
						<u>Elk</u>	<u>Deer</u>
Putr	1968	1	88	96	68	-	-
	1969	2	86	96	61	30	26
	1970	2	88	48	82	60	29
	1971	2	58	78	75	25	14
	1972	2	26	64	48	30	28
	1973	2	16	62	40	34	26
Salix	1968	2	80	98	88	-	-
	1969	2	82	88	88	-	-
	1970	2	76	96	90	-	-
	1971	2	54	82	89	-	-
	1972	2	56	92	82	-	-
	1973	2	40	76	90	-	-
Aspen	1968	1	45	40	-	-	-
	1969	1	32	59	81	-	-
	1970	1	63	65	85	-	-
	1971	1	40	62	82	37	-
	1972	1	53	79	72	34	-
	1973	1	10	62	80	-	-
Grass	1969	3			-	42	4
	1970	3			62	59	0
	1971	3			41	45	0
	1972	3			50	27	0
	1973	3			72	52	0
Meadow	1969	2			-	32	0
	1970	2			16	47	0
	1971	2			48	34	0
	1972	3			44	42	0
	1973	3			61	83	0

Table 3. Forage Utilization and Range Use on Beaver Brook Drainage

<u>Species</u>	<u>Year</u>	<u>Trans.</u>	<u>% Hedged</u>	<u>% Decadent</u>	<u>% Util.</u>	<u>Days use/acre</u>	
						<u>Elk</u>	<u>Deer</u>
Putr	1968	2	46	60	60	-	-
	1969	4	66	73	63	18	18
	1970	4	81	22	62	11	21
	1971	4	46	45	30	13	10
	1972	4	22	49	19	14	24
	1973	4	28	65	38	39	44
Artr	1968	3	36	37	25	-	-
	1969	3	35	55	24	13	4
	1970	3	57	33	21	38	10
	1971	3	37	55	12	29	14
	1972	3	8	37	11	27	4
	1973	3	5	51	22	27	0

Table 3 contd. Forage Utilization and Range Use on Beaver Brook Drainage

Species	Year	Trans.	% Hedged	% Decadent	% Util.	Days use/acre	
						Elk	Deer
Aspen	1968	2	21	5	-	-	-
	1969	2	48	52	62	-	-
	1970	2	61	68	86	-	-
	1971	2	35	39	84	47	6
	1972	1	15	53	48	-	-
	1973	1	20	35	80	-	-
Salix	1968	1	92	80	85	-	-
	1969	1	96	96	88	-	-
	1970	1	88	80	85	-	-
	1971	1	60	100	90	57	0
	1972	1	100	92	90	50	0
	1973	1	96	88	89	-	-
Grass	1969	2			-	23	0
	1970	3			74	40	0
	1971	3			41	25	10
	1972	3			27	21	1
	1973	3			56	30	0
Meadow	1969	1			-	33	0
	1970	1			72	40	0
	1971	2			57	45	0
	1972	2			38	57	0
	1973	2			84	60	0

Table 4. Forage Utilization and Range Use on Fall River Drainage

Species	Year	Trans.	% Hedged	% Decadent	% Util.	Days use/acre	
						Elk	Deer
Putr	1968	1	64	72	84	-	-
	1969	1	84	36	70	40	13
	1970	1	100	16	84	37	33
	1971	1	92	64	90	27	34
	1972	1	64	28	80	13	13
	1973	1	68	96	80	17	27
Salix	1968	2	52	28	65	-	-
	1969	2	48	6	60	-	-
	1970	2	44	62	64	-	-
	1971	2	30	78	61	-	-
	1972	2	36	64	58	-	-
	1973	2	32	54	48	-	-
Aspen	1968	1	15	28	-	-	-
	1969	1	25	32	57	-	-
	1970	1	40	75	59	-	-
	1971	1	35	45	77	54	0
	1972	1	47	56	54	70	3
	1973	1	20	62	41	13	0
Grass	1969	1			-	32	0
	1970	1			71	42	0
	1971	2			58	37	0
	1972	1			75	36	3
	1973	1			55	28	2

Table 4 contd. Forage Utilization and Range Use on Fall River Drainage

Species	Year	Trans.	% Hedged	% Decadent	% Util.	Days use/acre	
						Elk	Deer
Meadow	1969	1			-	87	0
	1970	1			58	154	0
	1971	3			61	91	0
	1972	3			47	98	0
	1973	3			51	85	0

Table 5. Changes in Percent Canopy Cover and Frequency of Selected Plant Species on Ponderosa pine/Shrub vegetation type

Location		Mill Creek	Moraine Park	Beaver Meadows	Horseshoe	Total
No. of Transects		2	2	3	1	8
Bare ground	1968	16/78	12/72	9/54	13/76	12/7
	1973	14/88	8/66	6/46	6/67	8/6
<i>Purshia tridentata</i>	1968	16/52	12/38	16/51	16/43	16/4
	1973	29/66	22/50	22/48	18/48	24/5
<i>Ribes cereum</i>	1968	2/3	1/3	5/8	3/6	4/1
	1973	2/3	2/10	3/8	2/7	2/5
<i>Agropyron</i> spp.	1968	2/7	6/54	12/71	6/38	7/4
	1973	3/31	8/59	12/64	-/-	8/4
<i>Muhlenbergia montana</i>	1968	16/52	4/12	13/49	25/86	13/5
	1973	15/50	3/12	15/70	29/95	14/5
<i>Stipa comota</i>	1968	1/7	1/22	1/16	-	1/1
	1973	1/15	4/31	2/19	tr/19	2/2
<i>Carex</i> spp.	1968	6/48	2/19	2/19	5/38	3/2
	1973	6/60	3/34	5/26	5/48	5/3
<i>Eriogonum umbellatum</i>	1968	1/25	1/26	3/27	-	2/4
	1973	1/24	2/31	3/27	-	2/2
<i>Artemisia frigida</i>	1968	2/36	4/40	4/38	1/14	3/3
	1973	2/24	3/43	4/37	2/14	3/3

Table 6. Changes in Percent Canopy Cover and Frequency of Selected Plant Species on Grassland Vegetation Type

Location		Beaver Meadows	Horseshoe Park	Moraine Park	Total
No. of Transects		4	2	2	8
Bare ground	1968	20/87	12/55	10/95	17/81
	1973	12/82	12/62	8/86	11/78
<i>Chrysothamhus viscidiflorus</i>	1968	3/24	-	-	2/12
	1973	3/14	-	-	1/9
<i>Agropyron</i> spp.	1968	5/59	13/48	3/34	9/63
	1973	8/55	4/28	5/40	11/59

Table 6 contd. Changes in Percent Canopy Cover and Frequency of Selected Plant Species on Grassland Vegetation Type

Location No. of Transects		Beaver Meadows 4	Horseshoe Park 2	Moraine Park 2	Total 8
<i>Muhlenbergia montana</i>	1968	15/74	6/43	5/41	10/58
	1973	17/75	5/40	4/31	10/55
<i>Stipa comata</i>	1968	5/52	1/12	13/90	6/52
	1973	4/58	2/19	14/88	6/56
<i>Bouteloua gracilis</i>	1968	6/47	2/14	8/74	6/46
	1973	6/49	1/12	10/86	6/49
<i>Artemisa frigida</i>	1968	4/71	11/93	4/64	6/75
	1973	4/68	9/72	11/93	7/75
<i>Selaginella densa</i>	1968	4/67	7/42	9/60	6/43
	1973	8/73	9/50	10/62	7/46

Table 7. Changes in Percent Canopy Cover and Frequency of Selected Plant Species on Four Sagebrush Transects

Location		Beaver Meadows	Lower Deer Mtn.	Upper Deer Mtn.	Hallowell	Total
Bare ground	1968	13/95	4/43	7/33	13/81	9/63
	1973	14/76	5/33	5/62	20/95	11/66
<i>Artemisia tridentata</i>	1968	20/62	32/90	21/72	29/71	26/74
	1973	13/43	38/90	23/67	21/71	24/68
<i>Purshia tridentata</i>	1968	-	-	2/5	4/24	2/7
	1973	-	tr/5	4/10	12/48	4/16
<i>Chrysothamnus viscidiflorus</i>	1968	2/10	1/24	tr/5	2/24	1/16
	1973	2/10	1/24	-	4/19	2/13
<i>Carex</i> spp.	1968	2/33	12/76	17/81	20/90	13/70
	1973	2/33	18/76	18/86	11/86	12/70
<i>Stipa comata</i>	1968	1/38	tr/10	1/24	tr/5	1/19
	1973	2/24	tr/5	5/24	1/10	3/16
<i>Agropyron</i> spp.	1968	6/76	6/62	17/90	2/19	8/61
	1973	15/95	15/86	15/76	7/48	13/76
<i>Muhlenbergia montana</i>	1968	7/43	7/43	6/29	3/19	6/34
	1973	10/48	12/67	14/52	5/33	10/50
<i>Eriogonum umbellatum</i>	1968	1/19	1/19	3/38	2/29	2/26
	1973	2/38	1/14	3/33	3/33	2/29

Table 8. Plants per Acre Density of Aspen on four transects

Location	Lower		Upper		Moraine Park	Horseshoe Park
	Beaver Meadows		Beaver Meadows			
Mature*	1970	204	60	-	-	87
	1973	215	37	23	-	53
Young	1968	2117	549	973	973	1191
	1973	1778	289	1094	1094	959

\*Plants over 8 ft tall

Table 9. Line Intercept of Shrubs on Five Willow Transects\*

Location		Upper		Upper	Lower	Hallowell Park
		Horseshoe Pk	Beaver Meadows	Moraine Pk	Moraine Pk	
Willow	1968	66	26	64	21	147
	1973	76	36	55	14	134
Bog birch	1968	17	-	12	-	1
	1973	13	-	14	-	tr
Alder	1968	-	-	-	-	16
	1973	-	-	-	-	18

\*200-ft transects except Lower Moraine Park is only 100-ft.

# # #

UNGULATE ECOLOGY STUDIES  
ROMO-N-13

INVESTIGATOR: David R. Stevens

OBJECTIVES: To determine the year around distribution, habitat use, and food habits of elk, deer, and bighorn sheep in Rocky Mountain National Park; to obtain quantitative data on population dynamics of the three species; to obtain data on other ecological relationships; to provide data for management of these species and their habitats.

METHODS: Determine distribution, habitat use, and food habits through (a) periodic field observation trips to record location, activity, vegetation type, exposure, weather conditions, and other pertinent data on animals observed; (b) aerial observations by helicopter as often as feasible to supplement ground observations; (c) observe feeding animals and examine feeding sites for plant use; and (d) collect rumen samples from any accidentally killed or poached animals and analyze for food habit data.

Determine population characteristics by (a) recording sex and age classifications from aerial and ground observations; (b) trend counts of population numbers, and (c) observation of winter mortality.

Study ecology of species through (a) integration of data collected under vegetation and winter habitat studies; (b) direct observation of intraspecific relationships; and (c) direct observation of animal behavior.

RESULTS: Work on this study was limited in 1973, as emphasis was placed on other projects. Observations to determine range use and movements were made on 1220 elk in 252 groups from the ground. Aerial observation flight by helicopter recorded 363 elk in 26 groups.

The winter was characterized by about average temperatures but less precipitation than normal on the east slope. The snowpack in March and April was therefore lower than the long-term average. Distribution of animals related to weather conditions also remained similar to normal years.

Food habits for elk were studied on 13 feeding sites on 4 vegetation types. Emphasis was put on obtaining food habit data on the alpine tundra type. Six feeding sites were examined on the alpine of Trail Ridge (Table 1). Key plant species utilized on these sites were *Carex rupestris*, *Kobresia myosuroides*, and *Poa* spp.

Reproduction in the elk population was determined by ground classification counts. The calf:cow ratio was quite low this year at 20:100. This could be both an indication of reduced production but also greater survival of calves the previous year. This reduced level, however, is to be expected as the population builds toward range carrying capacity.

Hunting season results outside the park for 1972 season (Table 2) indicated a fairly good harvest, removing more than the minimum believed necessary. The season for 1973 did not appear to be as good. Although the regular season which was "specified" for 300 males and 100 females may have been better than normal, the post season was not held, due to insufficient snow being present in early December to move elk out of the park.

For deer, 286 animals were recorded in 43 groups. The wintering deer population within the park continues to remain fairly low. (See report on range conditions, ROMO-N-08a). Deer food habits were studied on six feeding sites and four vegetation types.

Reproduction in the deer population appears lower than in the past. The fawn:doe ratio in 1972 was 77:100 while the ratio this year was 44:100. Again the high survival of fawns in 1972 could just be being reflected in this figure.

Compilation of data for the 5-year report was initiated.

PLANS FOR 1974: Concentration of effort will be on food habits and range use of summer range. Work on a 5-year report on the Ecology of Elk and Deer will continue.

Table 1. Food habits of elk on alpine tundra winter range as determined by six feeding site examinations in 1973.

No.	257	261	262	263	266	267	Average
Date	1/3	1/23	1/23	3/7	3/20	3/20	6
Veg. Type	<i>Kobresia</i> Assoc.	Fellfield	Fellfield	<i>Carex</i> Assoc.	<i>Kobresia</i> Assoc.	Fellfield	
<u>No. Inst. Use</u>	<u>111</u>	<u>130</u>	<u>127</u>	<u>111</u>	<u>127</u>	<u>139</u>	<u>745</u>
Plant species							
Salix spp.	18						3/16
TOTAL BROWSE	18	0	0	0	0	0	3/16

Table 1 contd. Food habits of elk on alpine tundra winter range as determined by six feeding site examinations in 1973.

No.	257	261	262	263	266	267	Average
Date	1/3	1/23	1/23	3/7	3/20	3/20	6
Veg. Type	<i>Kobresia</i> Assoc.	Fellfield	Fellfield	Assoc.	<i>Kobresia</i> Assoc.	Fellfield	
<i>Arenaria fendleri</i>	1					2	tr/33
<i>Artemisia</i> spp.	1						tr/16
<i>Potentilla</i> spp.	1				2		tr/33
<i>Geum rossii</i>		9	6				2/33
<i>Silene acaulis</i>			5				1/16
Other Forbs	7	9	2	3	1	5	5/100
<b>TOTAL FORBS</b>	<b>10</b>	<b>18</b>	<b>13</b>	<b>3</b>	<b>3</b>	<b>7</b>	<b>8/100</b>
<i>Danthonia</i>		2	4	10		2	3/67
<i>Poa</i> spp.	11	15		56	17	17	19/83
<i>Agropyron</i> spp.	4						1/16
<i>Carex rupestris</i>	53	53	68	15		8	33/83
<i>Carex elynoides</i>	4	12	4	2			4/67
<i>Carex</i> spp.			2		5	7	2/50
<i>Kobresia myosuroides</i>					75	60	23/33
Other grass or grass-like			9	14			4/33
<b>TOTAL GRASS</b>	<b>72</b>	<b>82</b>	<b>87</b>	<b>97</b>	<b>97</b>	<b>93</b>	<b>89/100</b>

Table 2. Elk hunting seasons outside the park

Year	Type Season	Area	Dates	Permits	Harvest
1972	Preseason (Primitive Weapon)	MM	9 Sept.-23 Sept.	-	10
	Regular season	T	28 Oct.-12 Nov.	150 females (unlimited males)	196
	Post season	T	16 Dec.-31 Dec.	250 females	121
	TOTAL			400	327
1973	Preseason	MM	September -	300	-
	Regular season	T	27 Oct.-11 Nov.	300 males 100 females	-
	Post season	T	December -	Unfilled	Canceled

# # #

GREENBACK RESTORATION STUDY  
ROMO-N-20

INVESTIGATORS: David R. Stevens  
David Butts  
James Mullan

OBJECTIVES: To test methods of removing brook trout from stream-beaver pond complexes on east slope of park; to reestablish pure greenback trout in at least one accessible drainage for demonstration purposes, and to provide transplanting stock; to determine feasibility of restoration of greenback into the other native habitats.

METHODS: Treat Hidden Valley Creek with fish toxicant to remove brook trout; release wild greenback trout obtained from a tributary of North Boulder Creek to reestablish a population; monitor the success of the restoration.

RESULTS AND DISCUSSION: The first phase of the restoration of the greenback trout (*Salmo clarki stomias*) to Hidden Valley Creek was completed the week of 10-15 September. As proposed by memo with a negative declaration of environmental impact on 2 February 1973, the treatment for removal of brook trout (*Salvelinus fontinalis*) was made with various forms of antimycin A and detoxified with potassium permanganate.

Treatment was started at 5:00 p.m. 10 September in the west fork of the creek with the placement of a Fintrol cake and 8 oz of fluorescent yellow dye. This was repeated on the stream at the upper ski lift at 10:30 p.m. and at the Lodge culvert at 8:00 a.m. 11 September. Another cake was placed near the head of the beaver ponds at 11:30 a.m. Simultaneously on 11 September the upper beaver ponds and backwaters were treated with 9.25 cans of Fintrol 5 in sand form. By 5:00 p.m. numerous dead and dying fish were noted in the upper beaver ponds. No fish were found above the lodge culvert.

On 12 September the dye had moved into the lower beaver ponds but no dead fish were observed in the last large beaver pond at 8:00 a.m. From 3:00 to 6:00 p.m. two units of Fintrol concentrate were added to the three lower beaver ponds and backwater areas. Dying fish were noted in these ponds at that time.

On 13 September at 8:00 a.m., the potassium permanganate stations on the Fall River Road culvert and Little Horseshoe road bridge were activated. Dead fish were noted throughout the drainage.

On 15 September at 8:00 a.m., dead fish were found at the confluence with Fall River in Hidden Valley Creek but none in the river itself. A check at 8:00 a.m., 17 September also revealed no dead fish in Fall River or Cascade Lake. The detoxification stations were removed at that time.

The Estes Park Water Department did not withdraw any water from Fall River from 8:00 a.m., 13 September to 8:00 a.m., 15 September.

All possible dead fish were retrieved from the beaver ponds and the stream. Most were measured and a good sample weighed and scales collected for age and growth studies. It was estimated that 50-75% of the fish by weight were collected. Most were brook trout, with a few mature long-nose suckers (*Catostomus catostomus*) from the lower meadow area.

Initial examination indicated the project was successful.

The second phase was accomplished on 16 October when 81 pure greenback trout (38, 4-6 inches and 43 over 6 inches) were caught by electro-fishing in Como Creek, a small tributary of North Boulder Creek (south of the park). They were transplanted by fish truck to Hidden Valley Creek. Release sites were just at head of first beaver dams and near maintenance building about halfway down the valley.

The stream was closed to angling by Superintendent's Order, 16 October 1973.

PLANS FOR 1974: The status of the reintroduction will be monitored closely in Hidden Valley Creek; other streams will be studied to determine one more test site.

# # #

#### AQUATIC RESOURCE SURVEY ROMO-N-02a

INVESTIGATORS: David R. Stevens                      James Mullan  
                  David Butts                                 John Klag

OBJECTIVES: To classify and describe aquatic ecosystems of the park; to determine the effects of sport angling on the ecosystem; to monitor angling pressures and harvest; to recommend management action necessary to maintain as natural ecosystem as possible and also provide a high quality angling experience to the visitor.

METHODS: Sample streams and lakes to determine composition of fish and other aquatic organisms; describe physical effects of angling on water and surrounding land area; conduct fishermen count and creel census to determine pressure and harvest.

RESULTS AND DISCUSSION: *Fisherman Interviews:* The fisherman interviews were continued in 1973 on the east side of the park on a more informal design. Because of the poor results in 1972 of interviewing successful fishermen, it was decided to interview as many fishermen as possible with no time schedule. Only one volunteer was used who had a personal interest in making the program succeed. The success of the interviews is shown in Table 1 and Table 2. A total of 1180 fishermen were interviewed, compared with only 276 in 1972. The catch per hour of effort remained identical at 0.59 fish per hour overall. The highest annual success was in Glacier Creek with 0.71 fish per hour, and the lowest in the Big Thompson with 0.51. The number of fish per fisherman, however, increased slightly from 0.90 in 1972 to 1.02 in 1973. Again 95% of the fish

caught were brook trout. Of these, 62% were 6-9 inches long. No brook trout over 12 inches appeared in the creel census.

Of the 1180 fishermen interviewed 53% were from outside the state of Colorado.

*Lake Surveys:* Lakes surveyed this year were Nanita and Nokoni in the North Inlet and Verna and Lone Pine in the East Inlet. The basic data has not been received from the Bureau of Sport Fisheries and Wildlife as of the writing of this report.

Both Lake Nanita and Nokoni maintain good populations of cutthroat trout. Since Nokoni has not been artificially stocked since 1967, it is believed that spawning success is sufficient to maintain the population with the present regulation.

In Lone Pine Lake and Verna, populations of eastern brook trout are thriving with no lack of reproduction.

*Stream Surveys:* Sections of the Colorado River and North Inlet sampled in 1972 were rerun. Fish caught by electro-fishing were tagged with internal anchor tags mounted just below the dorsal fin with a nylon T-bar inserted with a "tagging gun".

Fish were tagged in sections of the Colorado River at the Holzwarth Bridge and near the old Kawuneeche Residential Area. The North Inlet tagging section was at Summerland Park.

PLANS FOR 1974: Lake surveys will concentrate on Timber Lake on the west side and Thunder Lake in the St. Vrain drainage; a survey will be made of the fish in the headwaters of the Colorado River above Luly City to check on the presence of Colorado River cutthroat (*Salmo clarkii pleuriticus*); creel census will concentrate on the Colorado River and North Inlet in order to obtain tag results.

Table 1. Fisherman Success in East Slope drainages in 1973 creel census

Month	Res.	Non-Res.	Hours	Fish	Fish/Fisherman	Fish/hr.
<u>Big Thompson</u>						
May	28	6	57	93	2.73	1.63
June	21	81	176	36	.35	.20
July	24	52	125	63	.83	.50
Aug.	28	42	140	47	.67	.34
Sept.	15	2	54	42	2.47	.77
TOTAL	116	183	552	218	.94 (av.)	.51 (av.)
<u>Fall River</u>						
May	14	5	32	49	2.6	1.53
June	46	43	178	100	1.12	.56
July	46	30	109	52	.68	.48
Aug.	22	23	76	41	.91	.54
Sept.	11	2	20	14	1.07	.70
TOTAL	139	103	415	256	1.05 (av.)	.62 (av.)
<u>Glacier Creek</u>						
May	7	-	12	6	.85	.50
June	15	33	74	45	.94	.61
July	42	28	124	87	1.24	.70
Aug.	19	25	54	49	1.11	.91
Sept.	1	5	8	7	1.16	.78
TOTAL	84	91	272	194	1.10 (av.)	.71 (av.)
GRAND TOTAL	339	377	1239	731	1.02	.59
	47%	53%				

Table 2. Fisherman success in lakes on East Slope in 1973 creel census

Month	Res.	Non-Res.	Hours	Fish	Fish/Fisherman	Fish/hr.
<u>Sprague Lake</u>						
May	13	9	52	33	1.50	.63
June	60	127	331	244	1.30	.74
July	69	77	274	135	.92	.49
Aug.	28	34	84	18	.29	.21
Sept.	7	6	29	2	.15	.07
TOTAL	177	253	770	432	1.00	.56
<u>Glacier Creek Drainage</u>						
<u>Lake</u>						
Mills	July	2	2	0	0	0
Jewel	July	2	6	0	0	0
Black	July	6	21	12	1.50	.57
<u>Big Thompson Drainage</u>						
Spruce	July	6	60	20	3.33	.33
Fern	July	3	10	4	1.00	.40
Loomis	July	3	21	30	10.00	1.42
<u>Fall River</u>						
Lawn	July	4	11	9	1.12	.82
Ypsilon	July	1	1	16	16.00	16.00

Table 3. Creel Census 1973

	Big Thompson	Glacier Crk	Fall R.	Sprague L.	Other	Total (%)
<u>Brook Trout</u>						
6	62	62	104	110	30	368 (30)
6-9	179	101	132	281	53	746 (62)
9-12	5	19	4	40	23	91 (8)
12	0	0	0	0	0	0 (0)
TOTAL	246	182	240	431	106	1205
<u>Rainbow</u>						
6	2	1		1	1	5 (33)
6-9	2	6	1	1		10 (67)
9-12						
12						
TOTAL	4	7	1	2	1	15
<u>Brown Trout</u>						
6	3	3	0			6 (19)
6-9	8	2	6			16 (52)
9-12	2	1	4			7 (23)
12	0	0	2			2 (6)
TOTAL	13	6	12	0	4	31
<u>Cutthroat</u>						
6						
6-9	17		1		14	32 (94)
9-12					2	2 (6)
12						
GRAND TOTAL	270	195	254	433	123	1275

## BACKCOUNTRY USER ATTITUDES, ROCKY MOUNTAIN NATIONAL PARK

INVESTIGATORS: Douglas L. Gilbert)  
James R. Fazio ) Colorado State University

SUMMARY OF PROGRESS: The majority of field work in this project was completed on 5 September following nearly 3 months in residence at Rocky Mountain National Park. During that period, approximately 800 useable questionnaires were obtained from applicants (both successful and unsuccessful) for backcountry use permits. The number of completed questionnaires was nearly triple this figure, but only one individual per party was selected (randomly) for inclusion in the survey. An additional 200 day hikers were included for comparison of selected characteristics.

Although I administered most of the questionnaires personally, to obtain sufficient day hiker numbers in the survey without sacrificing time from the Backcountry Office, it was necessary to hire a college student for about 8 days. However, enough time was actually spent in the backcountry to allow me to view the permit system from the visitor's standpoint as well as from that of an administrator and to obtain informal interviews and data relative to permit compliance, backcountry experiences, and miscellaneous management and user problems. I hiked 110 miles in the backcountry in connection with this phase of the project.

Finally, interviews were obtained from several employees involved in the backcountry permit system, including both Headquarters staff and field personnel. Standard visitor information was also obtained from all national parks currently known to administer backcountry-user controls.

*Experimental Phase:* Data from the pre-treatment questionnaires have been coded and key punched on computer cards.

The last group of post-treatment questionnaires were mailed 28 September. Returns in this part of the survey are currently running about 23% of the initial mailing, and a more satisfactory 65% after a follow-up letter. A minimal goal for returns is now set at 75%, or approximately 600 usable research subjects.

After a rough tally of returns, there appears to be an approximately even distribution between the major treatment classes (control group, brochure group and slide exhibit group). An apparent failure in the experiment is in the intended treatment class wherein visitors would have received the brochure from a "ranger" in the backcountry during their visit. Little enthusiasm for this aspect of the project was expressed by backcountry field personnel; and to date, only one return has indicated that the brochure was received from a ranger in the backcountry. Equally disappointing to date (although hypothesized) has been the low number of visitors who viewed the educational television production (broadcast from three Colorado cities) or read the newspaper feature article (which received excellent handling by the editors of newspapers in Fort Collins, Estes Park, Boulder, and Denver). However, while sufficient numbers may not be obtained in these latter classes for significant testing and comparison, there is, nonetheless, much to be learned from these results which will be helpful for overall evaluation and recommendations.

*Evaluative Phase:* Evaluation of the permit system, through observation, participation, and interviewing, is proving to be more complex but, at the same time, more revealing than anticipated. Especially noteworthy is the complicating factor of having to deal with a dynamic, continually changing system. For example, many badly needed efficiency adjustments were, or are, being made by the backcountry staff as rapidly as the problem is discovered and a possible solution determined. This independent and "parallel evolution" was impressive in most cases, and the interest of the Headquarter staff in making improvements in the system is encouraging and commendable. In a few instances, however, plans for adjustments are counter to those which will be proposed in the final report of this project. Consequently, it may be more efficient and beneficial in the long run to postpone any major changes until completion of this project.

Use of the so-called "participant-observer" technique and informal contacts in the backcountry with other hikers and campers has proved to be much more significant than anticipated. Numerous flaws in the system and other management problems or deficiencies became known through this part of the project. Paramount in these findings is the problem of backcountry patrolling and law enforcement. Although a rough documentation of compliance indicated that a very high percent of the park visitors actually had permits, a check of campsites showed that it was possibly more "an exception than a rule" when the number of parties at a particular site matched the number recorded in Headquarters for that site on the same night. This indicates a high degree of permittees either at a site other than the one for which their permit was issued, or failing entirely to use their permit. The latter, especially, is a serious injustice when considering the large number of parties turned away for lack of sites during the summer months (for example, on 14 August more than 50 parties were unsuccessful in obtaining permits at the Headquarters issuing point alone). Varying attitudes on the part of employees toward enforcing the permit system, as well as insufficient staffing, also seem significant in this part of the evaluative research.

To date, interviews with park personnel have been somewhat confusing in their diverse results. With the exception of the need for a permit system, consensus on any one aspect of the program has yet to be noted. However, like the field contacts with visitors and the actual camping experience, the interviews are providing valuable insights to problems and solutions not otherwise known at the beginning of this investigation.

Mailed literature from other national parks having backcountry controls are likewise interestingly diverse. In some cases, the information received is so unclear that follow-up will be required just to determine what controls, if any, are in effect.

*Continuing Research:* Despite completion of the resident phase of the project, considerable work lies ahead. Questionnaire returns will continue to be solicited, received, and processed well into November. A computer program will be designed for data processing with an anticipated completion date of 31 December.

Other work which will continue through the winter includes:

1. Data analysis
2. Interviews with more park personnel involved with the system
3. Interviews with U.S. Forest Service personnel responsible for administration of land surrounding the park ("overflow" when sites in the park are filled are often directed to the less restrictive national forests surrounding the park)
4. Telephone calls, letters, or visits to compare the permit system in Rocky Mountain National Park with similar systems in other national parks, with a particular emphasis on the success of various modifications such as advance reservations
5. Design of alternative approaches to issuing permits in the Backcountry Office
6. Review of park files and records to describe the development of the present permit system in RMNP and to document enforcement policy and history

# # #

## STUDY OF COLORADO MOUNTAIN BUTTERFLIES

INVESTIGATOR: Robert G. Simpson  
Colorado State University

SUMMARY OF PROGRESS: A reasonable number of butterflies were collected in the Rocky Mountain National Park this summer. Some of the representative families were Lycaenidae, Parnassidae, Pieridae, Nymphalidae, and Hesperidae. It was not, in general, a good season for butterflies in that the weather was cloudy and windy so many afternoons. This was especially true of the days I spent in the park.

PASSERINE BIRDS, PARTICULARLY HORNED LARKS, MAINLY IN ALPINE TUNDRA AREAS

INVESTIGATOR: Ronald A. Ryder  
Colorado State University

SUMMARY OF PROGRESS: Emphasis continues to be mainly outside Rocky Mountain National Park but limited data on nest establishment and times of occurrence in the park were obtained.

Limited field work will again be conducted in the park in 1974 primarily in conjunction with the Conservation Summit, at which time I would particularly like to be able to band.

My work in the park in 1973 was limited as I was on sabbatical leave in Newfoundland from August 1972 to July 1973. No birds were collected or banded in the park in 1973.

# # #

GEOLOGY OF ROCKY MOUNTAIN NATIONAL PARK

INVESTIGATORS: William A. Braddock) U.S.G.S. and C.U.  
James Cole )  
William Nesse ) C.U.  
John M. O'Neill )

SUMMARY OF PROGRESS: Jim Cole has completed field work in a region bounded by Odessa Gorge-Big Thompson River on the north, Continental Divide on the west, and North Ridge-Sandbeach Lake-Copeland Lake on the south. His work will be covered in detail in his Ph.D. thesis to be completed by December 1974. John O'Neill is working in the Mount Richthofen quadrangle and thus far has essentially completed mapping of the region north of Mt. Cumulus and west of the Grand Ditch. Bill Nesse has been studying the Pingree Park area north of the park but has extended his mapping about as far south as the north fork of the Thompson River. Braddock mapped the region bounded by Long Draw-Thunder Pass-Shipler Mountain-Cache la Poudre River.

Current plans for summer 1974 are for O'Neill to complete mapping of the Never Summer Mountains that lie within the park, and for Braddock to map in the Trail Ridge-Mummy Range area.

The majority of the bedrock within the park is composed of high grade metamorphic rocks intruded by granite. Both the metamorphic rocks and the granite are Precambrian (older than 1 billion years). The principal problems that will be investigated with regard to these older rocks are:

1. Can the metamorphic rocks be divided into different types that can be mapped as separate formations?
2. How many distinct periods of deformation of Precambrian age can be recognized? What is the geometry and distribution of folds and faults produced during episodes of Precambrian deformation?
3. Does the intensity of Precambrian metamorphism vary from place to place? How are the periods of metamorphism related to the periods of deformation?
4. Is there more than one age and type of granite? What are the mechanisms of formation and intrusion of the granite? Were some of the structures in the metamorphic rocks caused by the intrusion of the granite?

Within the areas mapped to date, the metamorphic rocks are primarily biotite-sillimanite schists and gneisses which cannot be separated into distinct formations.

Minor layers of hornblende gneiss do exist, but do not seem to continue for any great distance. Clear evidence for two periods of deformation have been observed in the north-west part of the park. The older period, which was apparently synchronous with the major time of metamorphism, produced folds trending northwest. No large folds of this period have been found, but nearly every outcrop contains small folds and mineral lineations of this stage. The younger period of deformation produced folds that plunge to the north-east. It seems probable that a very large syncline extends from the vicinity of Milner Pass northeastward toward the Mummy Range. The only granite that has been observed is the Silver Plume Granite which forms small bodies near Forest Canyon Pass and at the north end of Long Draw and large bodies in the Estes Park-Long's Peak area. The relations between Silver Plume and the metamorphic rocks in the area mapped by Cole are very complex. Here there appear to be multiple subhorizontal, sheet-like masses of granite separated by layers of metamorphic rock. The structure is quite complicated and different from that of adjacent regions. Interpretation of these features must await detailed analysis of the field data by Cole.

The mountain ranges that must have been produced during the periods of Precambrian deformation were eroded flat perhaps 600-1000 million years ago and then buried beneath younger sedimentary rocks. Marine shales and sandstones of Cretaceous (about 70-100 million years ago) age occur in the northern part of the Never Summer Mountains. These rocks are most spectacularly exposed in the Nokhu Crags, and also occur at the head of Skeleton Gulch and in Hitchen's Gulch. It appears that during the early stage of the formation of the present mountains, Precambrian rocks were moved upward and westward along the Never Summer thrust fault so that Precambrian rocks were placed above the Cretaceous rocks. These Precambrian rocks, resting above shale, are exposed on the ridge between Skeleton Gulch and Hitchen's Gulch. After the formation of the Never Summer thrust fault and during the Oligocene Period (about 28 million years ago), medium-sized bodies of igneous rock were intruded along the axis of the Never Summer range. These intrusives apparently arched up the already complexly faulted region and also thermally metamorphosed the Cretaceous shales to produce the hard material now exposed in Nokhu Crags and elsewhere. Simultaneously with the intrusion of the stocks in the Never Summers, there was fairly extensive outpourings of surface lavas which are preserved in the Iron Mountain-Little Yellowstone-Specimen Mountain area. Previous investigators concluded that Lulu Mountain and Specimen Mountain were rhyolite intrusions which marked the location of volcanic pipes. Our current work indicates that the so-called intrusives are actually extrusive welded tuffs, that there are no volcanoes either at Lulu Mountain or Specimen Mountain, and that the source of these surface lavas may have been the stocks of the Never Summer Range.

# # #

## A STUDY OF TORS IN THE HIGH MOUNTAINS OF THE FRONT RANGE, WITH SPECIAL REFERENCE TO THEIR VALUE AS AN INDICATOR OF NONGLACIATION

INVESTIGATOR: F. Alayne Street  
University of Colorado

SUMMARY OF Tor-like forms, broadly defined as free-standing rock outcrops isolated  
PROGRESS: by weathering and mass movement, were studied at high altitudes in the  
tundra and coniferous forest of the Colorado Front Range.

Air photo-mapping of alpine tors was carried out in three areas: Rocky Mountain National Park, Indian Peaks, and the Mt. Evans massif. Tors within the forest near Ward were mapped in the field.

The main controls on tor formation are geologic and topographic rather than climatic. The finest tors occur on massive, coarse-grained igneous rocks and granite-gneisses which are subject to granular disintegration. Tors in foliated metamorphic rocks are rarer and more irregularly shaped. The distribution of tors is markedly clustered. A statistical study of a 1/8 sample of alpine tor forms showed that their main locational

controls are rock type, slope, ridge trend, the geometry of drainage patterns and former alpine glaciers, topographic situation, and altitude. The last is the least influential. Long tor ridges, or "spines," are the most clustered. They group on long, gentle, east-trending interfluves between major Wisconsin glacier systems. Isolated tors develop more often on level summit plateaus, on valley sides, on shorter ridges, and on metamorphic bedrock. Tors below treeline dominate south-facing valley sides which postdate Plio-Pleistocene valley-cutting. Their forms are often irregular and individual tors harder to define.

Chemical weathering is occurring on tor surfaces and in deep, weathered profiles up to at least 3500 m. Small mineralogic changes in biotite, plagioclase, and hornblende are amplified by microfracturing into an extensive reduction in rock cohesion. The sandy debris produced is little leached, containing traces of illite-montmorillonite mixed-layer clay, kaoline, or halloysite. Well-formed tors are initiated below ground by granular disintergration and spheriodal weathering which continue during and after subaerial emergence. Deep grussification and hydrothermal alteration, although present at some tor sites, are not necessarily involved.

No tors stand within areas glaciated within the last 120,000 years, though tors were actively developing beyond the ice margins in glacial stades. The existence of tors within more ancient glacial limits is confirmed by an extensive literature search. Well-developed tors are, almost invariably, reliable indicators of Wisconsin ice-free areas, but no generalizations can be made about pre-Wisconsinan ice limits from the presence of tors.

# # #

#### THE EFFECT OF SNOW DEPTH ON TUNDRA VEGETATION

INVESTIGATOR: David M. Glenn

SUMMARY OF PROGRESS: Snow-depth measurements were taken throughout the winter of 1972-73. Vegetation analysis was not completed in the summer of 1973. This project will not be completed.

# # #

#### PREPARATION OF BOOK, FOREST TREES OF COLORADO

INVESTIGATOR: Gilbert H. Fechner  
Colorado State University

SUMMARY OF PROGRESS: Field collections nearly completed; all collections within park boundaries completed.  
Study is descriptive of native tree species.  
No funds are supplied; work should proceed as planned.

SOIL GENESIS ON LATE QUATERNARY MORAINAL SEQUENCES IN THE SOUTHERN  
AND CENTRAL ROCKY MOUNTAINS

INVESTIGATOR: Ralph R. Shroba  
University of Colorado

SUMMARY OF All of the necessary field work in Rocky Mountain National Park has been  
PROGRESS: completed. Thus far grain size, x-ray, percent organic matter, and heavy  
mineral analyses have been completed. A complete report will be sent to  
the park headquarters when the research has been completed.

# # #

THREE STADES OF NEOGLACIATION IN THE COLORADO FRONT RANGE

INVESTIGATORS: Sidney E. White and graduate students  
Ohio State University and University of Colorado

SUMMARY OF Since no money was available for this project in 1973, no field work was  
PROGRESS: possible; since transportation to Colorado from Ohio probably will not be  
possible in 1974, field work on the project will be delayed for several  
years. This is very regrettable, for the inclusion of the mapping of the three stades of  
neoglaciation into Rocky Mountain Park from areas being mapped south of the park would  
have led to the completion of a larger area showing the widespread nature of the three  
stades of neoglaciation.

When we can start mapping again, we will keep NPS posted on the progress being made.  
We are very pessimistic at this date about being able to undertake field work until we  
adjust to an older way of life, using bus/train travel and foot travel in the park to more  
numerous campsites for field work in each of the valleys to be mapped; this adjustment  
with financial support yet to be obtained may take several years.

# # #

A TAXONOMIC REVISION OF THE MOSS GENUS *PHILONOTIS*  
FOR NORTH AMERICA NORTH OF MEXICO

INVESTIGATOR: William M. Zales  
University of British Columbia

SUMMARY OF Although little time was spent in the park, several valuable collections  
PROGRESS: of *Philonotis* were made in the North Rim Meadows.  
In this type of organismal research, field work is extremely important  
but accessibility of critical field areas and limited time are major problems. The national  
parks provided the quick access that has increased our understanding of the genus *Philonotis*  
in its natural environment and the value of this research.

TAXONOMIC AND PHYTOGEOGRAPHIC SURVEY OF *SMELOWSKIA CALYCINA*  
(CRUCIFERAE) IN NORTH AMERICA

INVESTIGATOR: Craig W. Greene  
University of Alberta

SUMMARY OF PROGRESS: Recent cytological investigations of *Smelowskia calycina* in North America have revealed a disparity between northern and southern populations. The range of the diploid populations ( $2n = 12$ ) extends from the Swan Range in Montana southward to the southern limit of the range of the species in southern Colorado. Tetraploids ( $2n = 22$ ) extend from Glacier National Park northward, including Alaskan and Yukon varieties of the species. The southern diploid populations probably have the closest affinities to the diploids of mountainous Asia (Altai) and not to the northern tetraploids. The distribution pattern of these two chromosome races in mountainous North America and Asia suggests that they became established as the result of two separate interglacial migrations: the first migration established the range of the diploids to their present southern limits; the second migration established the tetraploids north of the diploids in the Arctic and in scattered localities south to Montana. The diploids have survived at least two separate continental glaciations only in the southern mountains; during a recent interglacial period the tetraploids arose from these and migrated north, extending their range to the Arctic; they survived the last glaciation in the Arctic and on scattered mountain *refugia* in the Canadian Rockies south to Montana.

No specimens of *Smelowskia calycina* were collected within Rocky Mountain National Park as a part of this study. The results of this research will be available in bound M.Sc. thesis at University of Alberta Library.

# # #

VEGETATION OF ROADCUT SLOPES IN THE TUNDRA OF ROCKY MOUNTAIN NATIONAL PARK

INVESTIGATOR: Andrew M. Greller  
Queens College

SUMMARY OF PROGRESS: The original project has been completed and a manuscript accepted for publication in the January 1974 issue of *Biological Conservation*. The author is identified as a collaborator of the NPS, and the great assistance of the Chief Park Naturalist, Mr. Dwight Hamilton, and other park staff members is acknowledged. Reprints of the article will be sent to the RMNP library as soon as they are available.

# # #

SURVEY OF VECTORS OF PUBLIC HEALTH IMPORTANCE - DEVELOPMENT OF  
VECTOR CONTROL MEASURES FOR RECREATION AREAS IN THE ROCKY MOUNTAINS

INVESTIGATORS: F. C. Harmston) U.S. Public Health Service, Fort Collins, Colorado  
L. J. Ogden )

SUMMARY OF            Because of budget limitations and shortages of personnel, no work was  
PROGRESS:            accomplished on this project during 1973. It is hoped that studies will  
                         be possible in the near future to acquire information on objectives as  
indicated by the title of this project.

# # #

#### SMALL MAMMAL AND BIRD COLLECTION FROM ROAD KILLS

INVESTIGATOR:    Jeffrey J. Hodge  
                         Shiloh High School, Eastern Illinois University

SUMMARY OF            Small mammals and birds--road kills--were collected for a public museum  
PROGRESS:            at Eastern Illinois University and for Shiloh High School. This last  
                         summer I preserved the following:

- 1 porcupine (*Erethizon dorsatum*)
- 1 big brown bat (*Eptesicus fuscus*)
- 1 pine squirrel (*Tamiasciurus douglasi*)
- 1 violet green swallow (*Tachycineta thalassina*)
- 1 tree swallow (*Iridoprocne bicolor*)
- 1 red-shafted flicker (*Colaptes cafer*)
- 1 sora rail (*Porzana carolina*)

These are now at Shiloh High School museum in Hume, Illinois.

Last summer I worked for NPS as a road patrolman in ROMO and SHMO, so I had first hand at the road kills. These road kills are usually discarded but I tried to make use of as many as possible. I am a biology teacher at Shiloh High School and do not get money for collecting. I would like to get as many mammals and birds as I can in the next four summers that I work in the area.

# # #

#### FEEDING ECOLOGY OF COLORADO WHITE-TAILED PTARMIGAN

INVESTIGATOR:    Terry A. May  
                         University of Colorado

SUMMARY OF            Field work within Rocky Mountain National Park was completed prior to  
PROGRESS:            1973. Therefore, I did not work within the park that year. I have  
                         completed data analysis and am now in the final stages of writing. The  
preliminary title of my Ph.D. thesis is Feeding ecology of White-tailed Ptarmigan in Colorado. This will be presented to Rocky Mountain National Park as soon as it is available.

COMPARISON OF THE CHANGE OF INSECT FAUNA IN RELATION TO THE CHANGE IN ELEVATION

INVESTIGATOR: Kent E. Mowrer  
Colorado State University

SUMMARY OF PROGRESS: Due to the gas shortage during the summer of 1973, Rocky Mountain National Park was not used as a trapping site for this project as originally anticipated.

# # #

SMALL MAMMAL SURVEY OF ROCKY MOUNTAIN NATIONAL PARK

INVESTIGATOR: Donald J. Nash  
Colorado State University

SUMMARY OF PROGRESS: No direct field studies were carried out within the boundaries of the park during 1973. It was felt that as a result of field studies that were made in the park during 1972 and as a result of collections made in other parts of Colorado during 1973, analyses of these data should be completed prior to commencing additional field studies. Laboratory analyses are now in progress.

One graduate student, Craig A. Ramey, completed his Ph.D. dissertation, Abert's squirrel in Colorado in September 1973.

Another graduate student, Richard N. Seaman, is expected to complete his dissertation on Immunotaxonomy of Sciuridae during 1974. His studies have included specimens taken in Rocky Mountain National Park.

# # #

SOIL CLAY MINERALOGY OF QUATERNARY DEPOSITS ON THE EAST SLOPE  
OF THE FRONT RANGE AND ADJACENT COLORADO PIEDMONT

INVESTIGATOR: Dennis I. Netoff  
University of Colorado

SUMMARY OF PROGRESS: Soil samples from glacial tills and outwash deposits in the Long Draw Reservoir area and portions of the St. Vrain drainage have been taken and the soil clay minerals have been X-rayed to determine type and relative abundance in those samples.

The X-ray diffractograms, however, have not yet been analyzed. Results should be available late this spring.

THE COMPOSITION AND DYNAMICS OF THE FORESTS OF THE EAST SLOPE  
OF ROCKY MOUNTAIN NATIONAL PARK

INVESTIGATOR: Robert K. Peet  
Cornell University

OBJECTIVES: 1. Preparation of a detailed description and classification of the forest vegetation of the east slope of Rocky Mountain National Park. This is to be done in the context of gradient analysis so as to provide a connective framework for interpretative activities as well as a simple predictive model for management purposes.

2. Determination and modeling of the dynamics of forest tree reproduction, size and age structure, productivity, and biomass as a function of stand age and site conditions. Management of forests in the strongly fire-dominated Rocky Mountains demands a detailed knowledge of the dynamics of post-fire succession. The study should provide a quantitative model of forest successional patterns where previously only speculation existed.

These two objectives, once satisfied, should provide information most valuable for park management planning. Only through the combined application of a detailed knowledge of forest composition and its expected change through time can sound management decisions be made.

METHODS: The descriptive study is to be based on a set of 300+ 0.1 ha sampling units systematically spread across the altitudinal, topographic-moisture, and stand-age gradients. Within each such unit all woody plants are counted and diameter at breast height (dbh) is recorded. Cover and frequency of herbaceous species is obtained from a subsample of 25 m<sup>2</sup> quadrats. All additional species in the 0.1 ha are also recorded.

The stand dynamics study is to be based on a set of approximately 30 sampling units of about 100 trees each. These stands are to be selected as six sets of five stands of differing ages on similar sites, with those six sets spread across the altitudinal gradient. At each site all trees will be cored at ground level to determine age, and each tree will be measured to determine height, bark thickness, rate of recent growth, diameter at ground height and dbh.

SUMMARY OF PROGRESS: The 303 required 0.1 ha-units for the first phase of the project have been collected and roughly two-thirds have been transcribed to IBM cards. Within these 303 units, the diameters of 53,882 tree stems over 1 m in height were measured. In addition, 7515 quadrats were sampled to obtain herb data. Many of the 1600+ specimens were collected as vouchers and will eventually be deposited in the park herbarium. These represent about 550 species, of which roughly 20 are new to the park species list prepared by Mrs Ruth Nelson. Determination of a number of difficult genera has not yet been finished. As soon as this is completed, the descriptive and classificatory stage can be actively pursued. A rough draft is anticipated for late May 1974.

Of the 30 required detailed stand samples, only 5 have been completed to date. These take 2 field-days each, so roughly 2 months of field work will be required to complete the second phase of the project. While a detailed data analysis has not yet been started for this phase, a number of unexpected and significant trends, not previously reported in the literature, have appeared. For example, under favorable site conditions a pulse type of post-fire regeneration is witnessed characterized by an initial flush of growth with a subsequent senescent stage with biomass and productivity decreasing to an eventual steady-state level. On less favorable sites, regeneration is much slower with biomass and productivity slowly increasing to the steady-state level the site is capable of supporting.

## AN ECOLOGICAL INTERPRETATION OF NORTH CENTRAL COLORADO

INVESTIGATOR: Terrance L. Cacek  
Colorado State University

SUMMARY OF PROGRESS: This investigation was part of my Ph.D. program at CSU. I have completed the thesis and published it for the Graduate School. I now hope to have it published by an independent book publisher. The remaining work in the park will be photographic work to illustrate the final publication.

# # #

### BIRD-BANDING RESEARCH

INVESTIGATORS: Allegra Collister) Denver Museum of Natural History  
Richard Esposito ) Colorado Division of Wildlife

SUMMARY OF PROGRESS: First phase of project completed; results of banding research on bird species in the park, observations of park personnel as recorded in park files, and winter bird counts as published in *American Birds*, all coordinated and incorporated in a booklet Birds of Rocky Mountain National Park, published in June 1970 by Denver Museum of Natural History. This booklet summarizes available information on abundance, seasonal status, and distribution of bird species in the park region. Serious observers will recognize that it is not a field guide, but should be used in conjunction with one of the very complete field guides available.

Future banding will be oriented toward providing material for a complete local guide and toward updating the Park Checklist as new observations are made.

Richard Esposito, sponsored by Colorado Division of Wildlife, and banding on a federal subpermit under my permit 6549, plans a thorough study of accipiters (mainly the Goshawk) in this region. He is an experienced bander who can make a valuable contribution in this field.

# # #

### STUDY OF THE CARICES OF ROCKY MOUNTAIN NATIONAL PARK AND COLORADO

INVESTIGATOR: Miriam F. Colson

SUMMARY OF PROGRESS: The random access punch card key for the Carices of Colorado is ready for the computer as soon as the key punch operator can complete his work. Some special work is being done at the Colorado University Herbarium on some *Carex* problems using park collections as well as collections from other parts of Colorado and North America.

Plants from the park have been pressed, identified, and labels typed. They will be delivered to Park Headquarters as soon as possible.

I will need a collecting permit for next year in order to continue the *Carex* study.

## ECOLOGY AND BEHAVIOR OF THE WILLIAMSON'S SAPSUCKER

INVESTIGATOR: Allen B. Crockett  
University of Colorado

SUMMARY OF PROGRESS: In 1973 I located nearly two dozen nests of the Williamson's Sapsucker and banded some 30 individuals. Additional behavioral and ecological data were gathered for both the Williamson's and Red-naped Sapsucker. I have written and submitted for publication (to the *Condor*) the first of several papers based on my findings.

This year will see the completion of my study, with emphasis on analysis of vegetation of preferred areas and a study of sap trees.

Copies of my published works will be provided.

# # #

## IMMUNOGENETICS OF SALMONID SERUM PROTEINS

INVESTIGATOR: Richard A. De Long  
Graceland College and Colorado State University

SUMMARY OF PROGRESS: In research completed for my doctoral thesis the following conclusions were reached:  
1. Salmonid serum albumins reacted with corresponding rabbit antisera using the technique of (2-D Single EID) two dimensional single electro-immunodiffusion were useful in demonstrating the degree of phylogenetic divergence between species from the subgenera *Oncorhynchus*, *Parasalmo*, *Salmo*, and *Salvelinus* in the subfamily Salmoninae.

2. Serum transferrins were found to be useful in delineating relationships between rainbow and cutthroat trouts and intraspecific groups of each. An F<sub>1</sub> hybrid (*S. clarki* x *S. gairdneri*) gave a transferrin pattern of partial identity for the *S. gairdneri* transferrin when reacted with a greenback cutthroat (*S. clarki stomias*) antiserum.

3. A unique pattern of partial identity with the formation of two spurs was obtained for transferrins from golden trout (*S. aquabonita*) and *S. clarki stomias*. A transferrin double partial identity pattern was considered to be supporting evidence that both species were derived from a recent common ancestor.

4. Transferrin genetic polymorphisms characteristics to *S. clarki* subspecies populations may be effectively analyzed using acrylamide-agarose gels and starch gel-agarose mixtures.

The cutthroat trout population in the Thompson River located in Forest Canyon, Rocky Mountain National Park, is essentially the native greenback cutthroat trout (*Salmo clarki stomias*) but with a slight introgression of the introduced Yellowstone cutthroat trout genotype (*Salmo clarki lewisi*) into the population (Wernsman 1973, M.S. thesis, Colorado State University). I would like to analyze the transferrins from the Forest Canyon greenback cutthroat population and make comparisons with transferrins from a greenback cutthroat population transplanted in Como Creek, Rocky Mountain National Park, from a small stream near the University of Colorado Science Lodge.

## STUDY OF SOIL AND AIR TEMPERATURE AND TREE GROWTH IN RELATION TO ELEVATION

INVESTIGATORS: Jay E. Anderson) NSF/BSCS Summer Institute  
Karen Hollweg )

SUMMARY OF This project was conducted as part of a summer institute for high school  
PROGRESS: biology teachers sponsored by the National Science Foundation and conducted  
by the Biological Sciences Curriculum Study and the University of Colorado.  
The purpose of the project was to provide a meaningful experience in field investigation  
to selected institute participants who expressed a desire to go beyond the usual "tour"  
of the area. Possible relationships between tree height, diameter, and age vs. elevation,  
air temperature, and soil temperature were investigated.

# # #

### AUTECOLOGY OF *Kobresia bellardii*

INVESTIGATOR: Katherine Bell  
University of Alberta

SUMMARY OF Research and thesis writing have been completed.  
PROGRESS:

SIGNIFICANT Findings are described in my thesis, a copy of which will be forwarded to  
FINDINGS: the park when it has been bound.

RECOMMENDATIONS: No further studies in the park are planned. Transplants made during  
the course of this study remain in place on Tombstone Ridge and I hope  
to check their condition after several years.

# # #

### ECOLOGY AND POPULATION DYNAMICS OF WHITE-TAILED PTARMIGAN

INVESTIGATOR: Clait E. Braun  
Colorado Division of Wildlife

SUMMARY OF Results of some aspects of the study have been published in technical  
PROGRESS: journal articles and a technical bulletin. Copies of all published  
papers resulting from the studies in Rocky Mountain National Park have  
been deposited in the park's library. Major objectives in 1973 were similar to those of  
previous years: (1) documentation through banding and reobservation fluctuations in  
populations of ptarmigan on the study sites adjacent to Trail Ridge Road; (2) assess the  
impact of June weather conditions upon nesting success and production. In 1973 only 29  
ptarmigan (primary young produced in either 1972 or 1973) were newly banded in Rocky  
Mountain National Park. This is the lowest number of any of the 8 years studied and  
illustrates the exceedingly low production in both 1972 and 1973. An additional 36 birds  
previously banded (as early as 1966) were either recaptured or reobserved. This number  
is identical to that of 1972 and suggests that there was no increase in mortality rates  
of banded birds from 1972 to 1973. The decrease in survival rates since 1969 apparently

stabilized in 1972-73. If mortality rates had not stabilized, major decreases in population levels observed in recent years could have been expected to continue. Unfortunately, there was no increase in production in 1973 and all data collected indicated that nesting success by the few hens present was less than 50%. Thus, it is expected that breeding densities will reach the lowest level of the 9 years of study in the spring of 1974. Reasons for the major decline in ptarmigan in Rocky Mountain National Park since 1969 are not clear, but weather conditions do not appear to be implicated. While the exact mechanism(s) are not easily identified, it is obvious that changes in survival rates of females and juveniles and nesting success of all females are the proximal factors involved. Working conditions in Rocky Mountain National Park have changed since 1971, making access to study areas more difficult. Because of such difficulties, it is anticipated that more time (the greatest since 1969) will be spent in the park in 1974 in order to maintain an adequate level of field investigations.

# # #

### GLACIAL GEOLOGY OF THE WEST SLOPE OF ROCKY MOUNTAIN NATIONAL PARK

INVESTIGATOR: Thomas C. Meierding  
University of Colorado

SUMMARY OF PROGRESS: Work performed during the summer of 1973 was concentrated on private land outside the park in the Colorado River drainage, but this work relates directly to the glacial history within the park. The research consisted primarily of sampling soils, boulders, and cobbles in order to determine the relative amounts of weathering of the glacial and fluvioglacial deposits. These studies have generally confirmed opinions on the deposit ages gained in research during previous summers, and they have increased confidence in detailed surficial maps completed this year by photointerpretation means (Shadow Mt., Trail Mt., Grand Lake, and Bowen Mt. quads). There are still many major problem areas which must be completed in detail before the story becomes clear.

Next summer's research will be the same type, but the area of study will be expanded to the entire upper Colorado drainage, including Monarch Valley (in the Shadow Mountain Recreation Area) and the terraces near the town of Granby. This work should help clear up some of the problems encountered in the glacial history of the Grand Lake area further to the north. A fairly complete glacial history (excluding holocene) of the upper Colorado River drainage is the goal of my Ph.D. dissertation. This dissertation and the surficial geological maps will be made available to the National Park Service upon completion.

My only requirement from NPS is a park entrance card and a collecting permit.

# # #

### PREDATOR-PREY RELATIONSHIPS AND NICHE PARTITIONING IN FIVE SPECIES OF INSECTIVOROUS BIRDS IN A HIGH MOUNTAIN FLOODPLAIN

INVESTIGATOR: Robert C. Eckhardt  
Cornell University

SUMMARY OF PROGRESS: During the summer of 1973, 616 person-hours were spent performing the following tasks: (1) A 35-ha area at the confluence of the Colorado River and Onahu Creek in Kawuneeche Valley was chosen as the primary

study area. (2) The study area was completely surveyed and flagged in a 125-ft grid and then mapped in considerable detail. This was done so that any bird sighted could be plotted on a master map with an error of no more than 25 ft, hopefully less. (3) Resident species of warbler (Wilson's and yellow) and flycatcher (willow and dusky, as well as Western Wood Pewee) were mist netted and marked with color bands--plus leg flags for the flycatchers--for individual recognition. A total of 80 individuals were so marked, some of which, of course, were lost as they migrated further up the valley. (4) The breeding territories of 37 pairs were carefully mapped. This includes essentially all resident pairs of the five species in the study area. Their breakdown is as follows: 18 pairs of Wilson's warbler, 4 pairs of yellow warbler, 3 pairs of Willow Flycatcher, 7 pairs of Dusky Flycatcher, and 5 pairs of Western Wood Pewee. Of these, 68% had at least one member of the pair color-marked. (5) Life history data on all five species was recorded throughout the summer. (6) Detailed stopwatch observations on predatory behavior in all five species were collected. Numerous aspects of the time budget and search and pursuit behavior were recorded. This is the most important and most time-consuming aspect of the study, one which will require at least three summers to accumulate a sufficient body of data. (7) A record of prey (insect) abundance and taxonomic composition was collected by means of three different methods throughout the season. (8) On nearby U.S. Forest Service land, 15 birds were collected and stomach contents preserved.

I spent most of this past fall in studying for, and passing, the qualifying exam for my Ph.D. Thus, unfortunately, little has been accomplished to date in terms of rigorous quantitative analysis of last summer's data. However, a number of qualitative generalizations can be made now with the realization that they may be modified or discarded in the future. I should note as well that simple observation at this point in no way implies causation; explanations as to why a certain theory is affirmed or denied will have to wait for one or two more field seasons.

A major part of my research involves searching and pursuing as two different approaches to predatory behavior and their implications on a number of aspects of avian life. I can make a few generalized comments on what the data appear to show. First, body size relationships within and between the two predatory guilds (searchers and pursuers) do not appear to be as simple or regular as originally expected. In fact, they are frequently the reverse of expectation. Second, as one might then surmise from the above finding, relationships in territory size are also not as expected in some instances although they are in others. Third, relationships in territory spacing and overlap appear to be more complex than originally anticipated, though this may be clarified somewhat by stomach content analyses and further observation. Fourth, time budgets do confirm the concept that warblers are searchers and flycatchers are pursuers (relative to each other). Further elaboration of predatory behavior will require more careful analysis of the data from the previous and coming summers. Additional data and observation in subsequent summers will strengthen the above generalizations and, more importantly, suggest reasons for their occurrence.

Several additional aspects of the study became apparent during the summer and after and will be more carefully investigated in following summers. Several of these involve the ways in which community organization may be influenced by year-to-year differences in weather, population sizes, food availability, etc. One aspect of particular interest revolves around the fact that the Willow and Dusky Flycatchers are sibling species (i.e., indistinguishable, even in the hand, except by call) living side by side in identical habitat--floodplain willow thicket. A pattern appears to be emerging by which these two species very subtly divide the available resources. Careful clarification of this will be a particularly challenging and theoretically important portion of my research.

In conclusion, my work for the coming two summers aims to accomplish the following: (1) build up a body of data such that significant statistical tests may be performed and results found; (2) determine the extent and influence of year-to-year variability on community organization; and (3) elucidate the sibling species problem.

COMPARISON OF BROOK TROUT POPULATIONS FROM TWO ROCKY MOUNTAIN STREAMS

INVESTIGATOR: David O. Norris  
University of Colorado

SUMMARY OF PROGRESS: Trout were collected and stomach analyses are in progress for 1973 (see attached sheet). Stream invertebrate analyses are also in progress. Fecundity data collected.

SIGNIFICANT FINDINGS: No definitive conclusions can be stated at this time but a pattern of fattening cycles was documented for both streams, differential growth rates are evident, and there appears to be a relationship with stomach contents and feeding patterns, but the latter is tentative as much of the data is still being analyzed.

RECOMMENDATION: Recommendations for 1974 include increasing frequency of sampling in certain months and dropping sampling in other months. Further, it would be most valuable to include a mark-recapture experiment to determine a population estimate at critical times of year and generate some data concerning movements.

MORAINE PARK: Brook trout

MALES	Date	n	Range in length	Range in weight	Mean condition <sup>a</sup>
	17 Jan	6	231-138	121.0-24.0	0.96
	11 Mar	7	280-151	168.0-28.0=	0.93
	21 Apr	10	229-133	121.0-26.0	1.00
	25 May	7	202-151	78.5-31.0	0.99
	29 June	7	163.0-96	49.5-10.0	1.15
	14 Aug	8	189-111	87.5-15.5	1.19
	19 Sept	9	226-110	138.5-14.5	1.16
	15 Oct	6	200-118	88.0-17.5	1.01

FEMALES

	17 Jan	7	225-120	99.0-18.0	0.91
	11 Mar	9	223-120	102.0-17.0	0.88
	21 Apr	6	237-171	99.5-43.0=	0.85
	25 May	9	223-120	112.0-16.5	0.96
	29 June	7	169-129	57.5-24.5	1.17
	14 Aug	8	179-135	69.0-26.5	1.21
	19 Sept	7	216-147	106.5-34.0	1.12
	15 Oct	10	226-130	112.0-22.5	0.97

<sup>a</sup>Standard error of the mean ranges from 0.016 to 0.029

MILL CREEK: Brook trout

MALES	Date	n	Range in length	Range in weight	Mean condition <sup>a</sup>
	25 Jan	6	192-135	68.5-22.4	0.91
	18 Mar	4	164-139	43.0-24.5	0.90
	18 May	7	185-132	75.0-22.0	1.02
	29 June	8	186-133	77.0-27.5	1.17
	21 Aug	9	196-122	83.5-23.0	1.15
	29 Sept	10	178-132	66.5-23.0	1.09
	19 Oct	8	185-119	76.0-18.5	1.01

FEMALES

	25 Jan	10	175-132	44.7-21.5	0.90
	18 Mar	12	260-144	162.5-28.0	0.83
	18 May	9	245-118	162.5-15.0	1.01
	29 June	8	198-142	91.0-34.0	1.13
	21 Aug	7	193-149	81.0-36.0	1.11
	29 Sept	6	213-148	87.5-35.5	1.01
	19 Oct	8	190-144	72.5-26.5	0.96

<sup>a</sup>Standard error of mean ranges from 0.018 to 0.034

## SAGUARO NATIONAL MONUMENT

### AN ORDINATION AND QUANTITATIVE ANALYSIS OF THE PERENNIAL VEGETATION SAGU-N-37

INVESTIGATOR: William H. Brooks  
Pima College

SUMMARY OF PROGRESS: Since the last report (December 1972) 15 additional stands have been selected, surveyed, and analyzed using the criteria stated in the original proposal. Total stands thus far selected represent major topographic features largely in the lower elevations of the Tucson unit. Collection of field data during the succeeding winter and spring months will concentrate in the higher elevations, again sampling major topographic features.

It is anticipated that a total of 35 stands will be completely tallied and worked into an ordination for community analysis after each of the stands has been surveyed and analyzed as to species importance with respect to the parameters of density, frequency, and cover.

No changes in the original proposal are anticipated at this time.

INVESTIGATION OF FACTORS REGULATING BIRD POPULATIONS AND DISTRIBUTION  
SAGU-N-24

INVESTIGATOR: Stephen M. Russell  
University of Arizona

SUMMARY OF I had one student working on the Saguaro Monument (west) study in spring  
PROGRESS: 1973. Pat Rusin followed nesting efforts of birds into May.  
I plan to use the study area in the Tucson Mountain section of Saguaro  
National Monument in the future.

# # #

HEIGHT-AGE RELATIONSHIPS IN THE SAGUARO CACTUS  
SAGU-N-28

INVESTIGATORS: S. M. Alcorn )  
J. R. Hastings) University of Arizona

SUMMARY OF An open-ended project. Measurements of selected plants in 60 acres at the  
PROGRESS: Saguaro National Monument (east) were again made in 1973.

# # #

TAXONOMIC STUDIES OF THE BACTERIAL SPECIES OF *ERWINIA CARNEGIEANA*  
IN COMPARISON WITH OTHER SOFT ROTTING ERWINEAS  
SAGU-N-20a, 9a, 15, 29

INVESTIGATOR: S. M. Alcorn  
University of Arizona

SUMMARY OF It is anticipated that the current phase of work on the taxonomy of the  
PROGRESS: soft-rot pathogen isolated from Saguaro and other cacti will be completed  
in 1974.

In 1972, 4.9% of the Saguaros in 60 acres of plots at the Saguaro National Monument  
(east) died from bacterial necrosis. In all, 44 plants died; 5 young plants were observed  
for the first time.

# # #

VIRUS DISEASES OF CACTI AND OTHER NATIVE PLANTS  
SAGU-N-19a

INVESTIGATORS: M. R. Nelson )  
Raymond Wheeler) University of Arizona

SUMMARY OF        Laboratory investigations of the saguaro virus continue, especially with  
PROGRESS:        regard to curious physical properties relative to the coat protein and  
                  the multiple component nature of the virus. Two separate groups of com-  
ponents exist, first, those based on sedimentation properties and second, those based on  
electrophoretic mobility. The biological significance of these properties is being  
investigated.

Year-to-year surveys of specific plants in the Saguaro National Monument (east) have  
shown that infection by the saguaro virus is increasing by annual rate of about 2%. While  
slow, this rate of spread will result ultimately in a large proportion of the saguaros in  
the monument becoming infected. Despite the lack of obvious morphological symptoms, such  
virus host relationships inevitably result in significant reduction in biological  
productivity. The classic potato virus X in potatoes, though completely symptomless,  
results in 20% reduction in productivity of infected potato plants.

We feel that the saguaro virus, because of distribution patterns, is a biological  
contaminant resulting from the introduction of cultivated plants into the desert biome.  
We are currently investigating the possible origin of this virus. The most promising  
host under investigation is the common geranium. Other workers in England and Spain have  
found viruses in geranium that resemble the saguaro virus. Geraniums of local origin  
are being investigated.

# # #

#### SURVEY OF DISEASES OF NATIVE ARID LAND PLANTS OTHER THAN THE SAGUARO SAGU-N-17

INVESTIGATORS: S. M. Alcorn )  
                  R. Gilbertson)     University of Arizona  
                  M. R. Nelson )

SUMMARY OF        Examination of fallen Ocotillo plants in the monument indicated a root-rot  
PROGRESS:        disease might be present as many plants have broken off at the ground line  
                  and a white rot was present in the roots and base of the stem. Isolation  
has yielded an unidentified Basidiomycete and further research is planned to establish  
its identify and relationship to root-rot in Ocotillo.

# # #

#### TO DETERMINE IF THERE IS A RELATIONSHIP BETWEEN PRECIPITATION, TEMPERATURE AND THE PERCENT OF YOUNG JAVELINA OBSERVED ON SURVEYS .SAGU-N-10a

INVESTIGATOR: G. I. Day  
                  Arizona Department of Game and Fish

SUMMARY OF        No significant correlation was found at the 10% level between 12 months of  
PROGRESS:        rainfall (1 November to 31 October) and percent of young javelina in the  
                  population sampled on the Saguaro National Monument (12 years). For the  
last 2 years, extreme rainfall variations occurred on the monument. This departure from  
the normal made the "water year" a poor indicator of javelina survival.

We plan to correlate young javelina survival and forage production estimates obtained on another area to see if the deviations in recent correlations can be explained. A multiple linear correlation analysis may be feasible.

Game Survey on Saguaro National Monument 19-29 November 1973

Observers: National Park Service and Arizona Department of Game and Fish

Man Days: 21

Javelina Classification

Adults.....	151
Juveniles.....	69
Total.....	220
Javelina not classified.....	20
Javelina herds counted.....	14
Avg. number javelina per herd.....	15.7
Percent juveniles in population.....	31.4
Largest herd count.....	26
Smallest herd count.....	5

Desert Mule Deer

Bucks.....	17
Does.....	51
Fawns.....	18
Unclassified.....	1
Total.....	87
Does per buck.....	3.0
Fawns per 100 does.....	35.3

Other Observations

Gambel quail coveys.....	39
Cottontails.....	37
Jack rabbits.....	4
Coyotes.....	3
Fox (gray).....	1
Bobcat.....	1
Mallard ducks.....	2

# # #

CRITICAL FACTORS DURING THE FIRST YEARS OF  
LIFE OF THE SAGUARO CACTUS IN SAGUARO NATIONAL MONUMENT  
SAGU-N-23a

INVESTIGATOR: Warren F. Steenbergh

OBJECTIVES: 1. To delineate and describe critical factors regulating germination and establishment of saguaro cactus in the principal habitats within Saguaro National Monument  
2. To determine the relative status and trend of saguaro seedling establishment in the principal monument habitats of this species.

METHODS: Field observations of wild seedlings and field germination and survival experiments were initiated at the eastern (Rincon Mountain) section of the monument in 1965. Experimental studies were extended to the western

(Tucson Mountain) section in 1967. Relative rates of seed attrition and germination success in various representative saguaro habitats were tested by broadcasting seed within preestablished plots and exclosures and observing the resulting germination under natural climatic conditions. After germination, periodic observation of seedlings was made to determine seedling growth, survival rates, and causes of mortality under these same conditions. Concurrent observations on relevant climatic, edaphic, and biotic factors were also made. Transplanted seedlings were also used to obtain additional data on seasonal mortality.

Observations on previously established seedlings were continued in 1969 together with small-scale seeding experiments to obtain further information on the effects of harvester ants, birds, and rodents. Limited trapping and field observation of rodents was done to obtain information on relevant habits of feeding and behavior. Periodic observations on transplanted pots of 4-month-old cultured saguaro seedlings were carried out to obtain information on climatically caused winter mortality.

Data on survival and freeze-caused mortality in natural and experimental populations of young saguaros in both east and west sections of the monument were obtained from 3 January to 21 November 1971. Observations were initiated concurrently with the onset of a period of subfreezing nocturnal temperatures from 3 January to 10 January.

**RESULTS AND DISCUSSION:** A report on the first phase of this study appears in *Ecology* (Steenbergh and Lowe 1969). Preparation of the final report on this project is in progress.

Freezing weather was the primary cause of winter deaths in all populations of known-age seedlings and juvenile saguaros observed during 1971. Total 1971 freeze-caused mortality in experimental populations of 30-month-old saguaros (n = 568) was 52.5%. Lowest mortality was on south-facing slopes. Highest mortality occurred on north-facing slopes and in flat habitats.

Mortality of seedlings and juvenile saguaros less than 120 cm in height was greatest in smaller (youngest) size-classes. Observable deforming injuries to stem tissues occurred in all height classes. Only plants less than 30 cm in height, however, were completely destroyed by freezing.

Limited follow-up observation made during 1972 indicates that death as a result of freeze-caused injuries can occur a year or more after initial injury.

A comprehensive report on winter mortality entitled The Ecology of the Saguaro: I. The role of freezing weather in a warm-desert plant population (Steenbergh and Lowe) was completed. The report is scheduled for publication by the National Park Service.

A bibliography on the saguaro has been submitted for publication and limited distribution by the National Park Service.

**CONCLUSIONS:** A summary and general conclusions are offered in the 1970 and 1971 reports on this project.

**PLANS FOR 1974:** Completion of the final report on this project planned for 1972 was deferred as a result of other assignments. Completion of a jointly authored monograph combining the results of this study with results of investigation by Charles H. Lowe is planned for 1974, to be published by the National Park Service.

#### References:

- Steenbergh, W. F., and C. H. Lowe. 1969. Critical factors during the first years of life of the saguaro (*Cereus giganteus*) at Saguaro National Monument. *Ecology* 50(5):825-834.
- \_\_\_\_\_. 1974. Ecology of the Saguaro: I. The role of freezing weather in a warm-desert plant population. AAAS Symposium on Research in the National Parks. In press.

POPULATION DYNAMICS OF THE SAGUARO CACTUS  
SAGU-N-26

INVESTIGATOR: Warren F. Steenbergh

OBJECTIVES: 1. Delineate and describe the existing saguaro populations of the monument in relation to the principal types of habitat and ecological situations in which they occur.  
2. Detect and measure long-term trends of these populations.

METHODS: Samples consisting of saguaros up to 1 m tall were selected from populations in each of the two sections of the monument, these to be used to establish size-age relationships, and to compare growth rates. All plants were measured in February 1969, February 1970, March 1970, and April 1971. All juvenile saguaro height measurements made to date have been recorded on computer punch cards and preliminary regression analysis was run.

A study involving photographic documentation and plot analysis of lightning damage to saguaro cacti was completed in 1970 (Steenbergh 1972).

A search for old photographs and historical records was undertaken. Saguaro study plots established at the east monument in 1941 were relocated for use in evaluating population trends. Photographs were taken to document the effects of freezing, grazing, fire, senescence, visitor impact and other factors on saguaros and saguaro habitat.

A study to determine saguaro reproductive-vegetative growth-rate relationships was initiated in 1969. Apical growth measurements of a sample of four saguaros approximately 4 m tall were made at regular intervals for one year. Two individuals used as controls were allowed to complete normal production of flowers and fruits. From the remaining two plants, flower buds were removed each week as they developed.

In 1971 a 2-ha (100 x 200 m) permanent sample plot was established in the lower bajada saguaro stand in the west monument. All saguaros were individually numbered and the condition of each plant was noted.

RESULTS AND DISCUSSION: Six 5-acre saguaro study plots at the east monument were located and partially reestablished. Approximately one-half of the original 1941 photo points of Paul C. Lightle have been relocated, subjects rephotographed, and permanent photopoint markers installed.

Photographic evidence indicates substantial recovery from livestock grazing has occurred in both rocky and nonrocky saguaro habitats from which cattle have been excluded since 1958.

Apical growth measurements on young saguaros (n = 35) (western section) revealed several causes of deviation from regression of normal growth.

A report on the rejection of bacterial rot by adult saguaro cacti has been published in the *Journal of the Arizona Academy of Science* (Steenbergh 1970). Six of seven adult saguaros effectively inoculated with the rotting organism (*Erwinia carnegieana*) recovered from the injury-associated rot. The seventh plant, apparently an unhealthy individual lacking normal vigor, died within 2 months after the first observation. A review of the published literature on the so-called "bacterial necrosis disease" indicates that the susceptibility of wild, healthy, adult saguaros to bacterial infection was not tested by investigators.

The report on lightning-caused saguaro mortality was published in *The Southwestern Naturalist* (Steenbergh 1972). Lightning-caused destruction of saguaro cacti in the Tucson Mountains population is estimated at 0.51 to 3.18 plants per ha (0.6 to 4.0%); saguaro biomass converted, 520 kg to 2840 kg per ha (1.1 to 5.8%). Based on these values

for lightning-caused mortality only, the biomass turnover period for this population is 17.2 to 93.1 years.

Apical growth rate studies indicate that energy for reproductive growth is utilized at the expense of vegetative growth. Thus, it can be expected that (1) under a uniform environment, nonblooming individuals will grow at a faster rate than blooming individuals of the same size and age, and (2) a change in the relationship between size and growth rate can be expected when young plants reach blooming size. This relationship must therefore be reflected in projections designed to provide estimates of plant age based on size.

In 1971, 6.35% of the saguaros (n = 189) in the 2-ha Tucson Mountain plot died from freezing. Complete results of 1971 studies are reported in a manuscript entitled Ecology of the Saguaro: I. The role of freezing weather in a warm-desert plant population (Steenbergh and Lowe 1974).

**CONCLUSIONS:** Healthy adult saguaros do not die from bacterial rot; natural response to injury confines bacterial rot to stressed or mutilated tissues immediately adjoining the site of the injury. Destruction by bacterial rot occurs in saguaros which are dead, senescent, or otherwise lacking in normal vigor.

Lightning is an important cause of adult saguaro mortality. Physical evidence of lightning damage to saguaro cacti is distinctive. However, delayed examination can easily lead to the invalid assumption that death of the stricken saguaro is attributable to "bacterial necrosis disease" or other inappropriate causes.

The absence of reported lightning-caused mortality in the only published report on specific causes of adult saguaro mortality (Alcorn and May 1962) is attributed to failure to recognize and distinguish between lightning and other climatically caused saguaro deaths, and the disease-like characteristics of subsequent natural decomposition; such deaths having been erroneously attributed to the so-called "bacterial necrosis disease."

Conclusions concerning the role of freezing weather in the regulation of Saguaro National Monument are contained in the report on Project SAGU-N-23a. Observations made during 1972 and 1973 indicate that death of adult saguaros continues to occur for several years after the occurrence of a severe freeze (Fig. 1).

**PLANS FOR 1974:** Continue growth measurement studies. Continue rephotography and photo documentation. Available applicable results will be incorporated in the final report on Project SAGU-N-23a.

#### References:

- Alcorn, S. M., and C. May. 1962. Attrition of a saguaro forest. *Plant Dis. Rep.* 46(3):156-158.
- Steenbergh, W. F. 1970. Rejection of bacterial rot by adult saguaro cacti (*Cereus giganteus*). *J. Ariz. Acad. Sci.* 6(1):78-81.
- \_\_\_\_\_. 1972. Lightning-caused destruction in a desert plant community. *Southwest. Nat.* 16(3/4):419-429.
- Steenbergh, W. F., and C. H. Lowe. 1974. Ecology of the Saguaro: I. The role of freezing weather in a warm-desert plant population. AAAS Symposium on research in the national parks. In press.

#### Publications:

- Steenbergh, W. F. 1972. Lightning-caused destruction in a desert plant community. *Southwest. Nat.* 16(3/4):419-429.
- \_\_\_\_\_. 1970. Rejection of bacterial rot by adult saguaro cacti (*Cereus giganteus*). *J. Ariz. Acad. Sci.* 6(1):78-81.

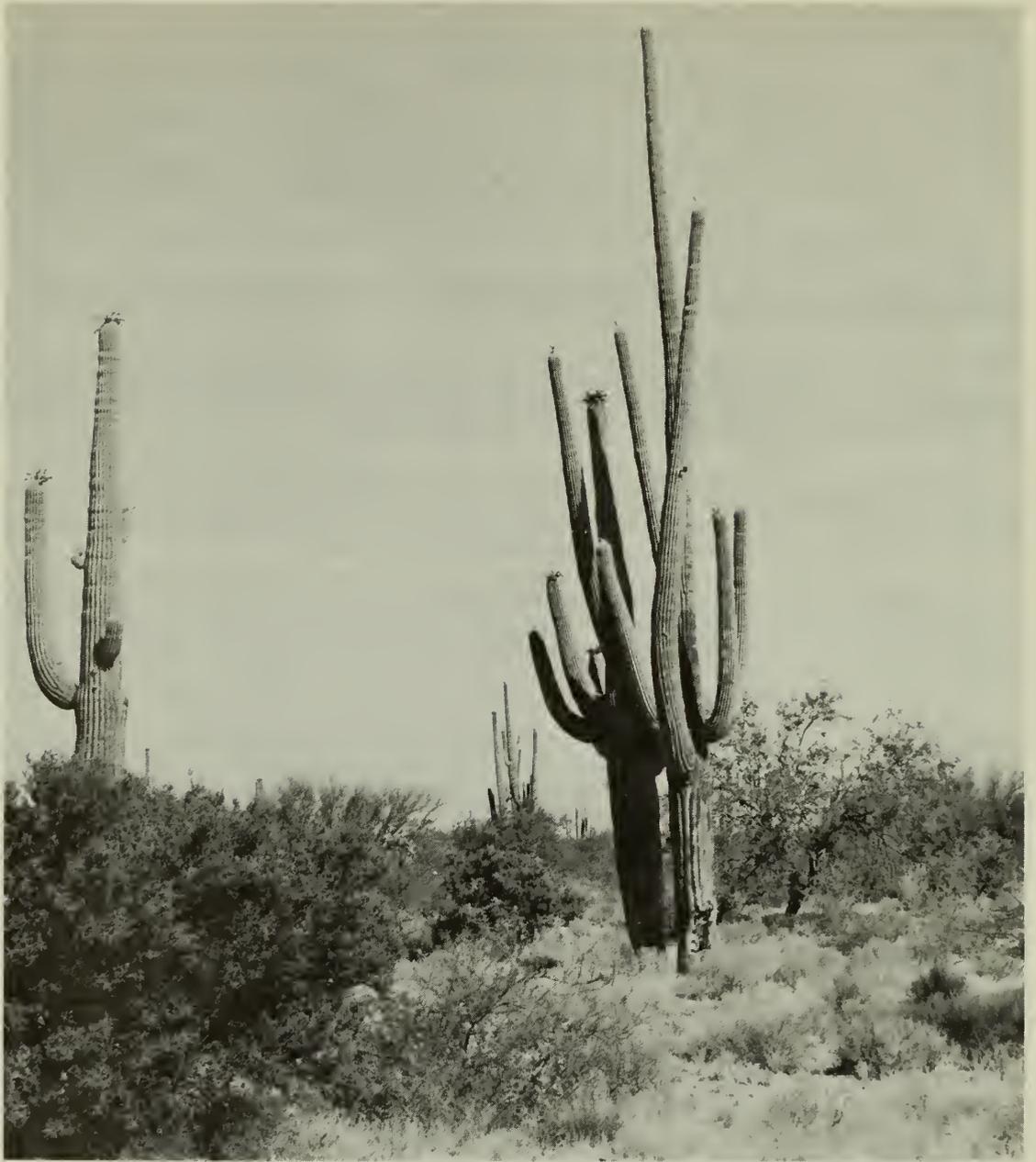


Fig. 1. The large, blooming saguaro on the right is dead. Up to a height of 1 m the stem tissues, completely dead, are in an advanced state of decomposition. Total collapse and decomposition occurred during the 3 months following.

Adult saguaros can offer the illusion of living plants for several years after they have been rendered physiologically dead in vital functions by lethal freeze damage at the stem base and root crown. The damage is concealed by woody scar tissues which surround the base of the stem; visual inspection may reveal no evidence of totally dead underlying tissues.

It is well known that not all parts of the plant die at the same moment. This time scale of organ death is greatly exaggerated in giant cacti.

Supported by the dead woody internal framework of the lower stem, the still-green and relatively undamaged upper portion of the stem continues to "live," even producing an annual crop of flowers and fruits from the abundant reserve of water and food stored within the succulent stem. The illusion of life continues either until wind snaps rotted roots or the stem base (revealing decayed woody support tissues), or until necrotic decomposition disintegrates the succulent tissues of the upper stem leaving only the standing woody skeleton of the plant. It is this effective illusion of life that has led pathologists in a long and vain search for the cause and cure of a decimating organismic "disease" that had no cure--for the "disease" which they sought to cure was in fact decomposition, and the cause was lethal freezing, its obvious effects too long delayed to allow their association with the catastrophic freeze of a forgotten winter.

## SAN JUAN ISLAND NATIONAL HISTORICAL PARK

### THE BIOLOGY OF THE RABBIT *ORCYTOLAGUS CUNICULUS* IN SAN JUAN ISLAND NATIONAL HISTORICAL PARK AND VICINITY SAJH-N-1

INVESTIGATORS: A. R. Weisbrod )  
W. Frederick Stevens) University of Washington

**SUMMARY OF** The European rabbit (*Oryctolagus cuniculus*) is the dominant mammal species  
**PROGRESS:** in the American Camp unit of San Juan Island National Historical Park. An  
introduced species (late 1800s), the rabbit establishes and maintains a  
zootic climax. Associated floral and faunal species appear to be directly and indirectly  
dependent on the rabbit. Objectives of this study include basic biological data about the  
rabbit, identification of cause and effect relationships in the ecosystem, measurement of  
the changes the rabbit has effected on the original ecotype, and estimation of the effect  
a management program would have on the system.

Standard biological and management techniques were employed in 1973 on the rabbit, its  
habitat, and associated animals of the area, particularly avian and ground predators.  
Emphasis was placed on measurement of plant species composition and diversity and seasonal  
changes related to rabbit-induced disruptions of plant succession. Experimental habitat  
manipulations proven highly informative, especially wire enclosures situated in various  
"mini-habitats" of the park.

**SIGNIFICANT** The rabbit is now firmly entrenched in the biological and human history  
**FINDINGS:** of San Juan Island, Washington. Our studies indicate that a combination  
of human and biological factors enable the rabbit to attain densities up  
to about 200/ha during the height of the breeding season. Its effects as the primary  
herbivore, in the areas in which it occurs, reach extremes to the degree it competitively  
excludes other herbivores (e.g., Blacktail Deer and slugs). Plant composition is limited  
to a very few species at any time of the year, the dominant species being two introduced  
European grasses. Succession is stopped at the early stages (small annuals and perennials)  
and, in some areas, is recycled back to the bare-earth stage because of the rabbits'  
digging habits.

The study has thus far provided a tentative description of the rabbit-induced "moss-  
moor" ecosystem typical of the region occupied by the rabbit in Europe. In addition, this  
ecosystem contains the only known breeding population of the Skylark (*Alauda arvensis*)

in the United States as well as a small feral population of the polecat or ferret (*Mustela putorius*) also of European origin.

No serious control experimentation was undertaken in 1973 nor is much planned for 1974. We feel that before management of the rabbit is effected, a firm understanding of the nature of the species and its environment is essential.

**RECOMMENDATIONS:** The primary function of this study is to gain information toward answering the question: "What will we do with the rabbit"? Firmly established in the island's socio-eco-biological structure, the rabbit presents a problem to the park owing to its high densities and feeding habits. Studies for 1974 include further intensive biological investigations into the nature of the species in order to define seasonal and yearly trends. Since 1973 was an extremely dry year, we have not yet defined a "normal" year in the rabbit's ecosystem. Accurate measurements of densities and dispersion are planned for the coming field season. Habitat and vegetation quantifications and, within the enclosures, potential species diversity measurements are planned.

Small scale control experiments in English Camp (where the rabbits are starting to invade) will be undertaken (albeit somewhat sooner than we had planned).

Detailed studies of the rabbit's population dispersal phenomena must be undertaken prior to initiation of any anticipated control measures because the success and frequency of such measures must consider the reinvasion and reestablishment rates and frequencies onto park lands from surrounding noncontrolled rabbit populations.

# # #

#### ESTUARINE STUDIES AND POPULATION DYNAMICS OF CLAMS

**INVESTIGATOR:** Vincent F. Gallucci  
University of Washington

**SUMMARY OF PROGRESS:** This project is a study of an estuary in the San Juan Archipelago which has been subject to intensive noncommercial clamming. Heaviest pressure is during the summer months when tourism is at its peak, although there is some pressure during other months. The bay in question is Garrison Bay on San Juan Island. The research is at the recently acquired San Juan Island National Historical Park, English Camp Unit.

The primary objectives of the study are to assess the current population size of the clams, to assess recruitment, growth, and mortality, to construct a management plan which will allow the population to maintain a sustainable yield, and to determine and implement conservation procedures that will minimize needless loss of clams. A secondary but important objective is to provide the public an alternative to year-round clamming. The alternative is that parts of the estuary which are easily accessible will be used for educational purposes in a sense similar to that of nature trails in national forest areas.

The first step was to choose a suitable statistical sampling scheme to evaluate the standing crop of clams of each species. A stratified random scheme was adopted. The estuary was subdivided according to sediment types (3 types) which happen to coincide with usage patterns. As areas are depleted, pressure shifts to alternate areas but the depleted areas are not allowed to recover.

Another step was to erect enclosures so that a contrast can be made between clammed and unclammed areas.

In the late summer, the State Department of Fisheries was approached about the possibility of instituting special clamming regulations and a management plan for Garrison

Bay. The proposed management plan was approved for the first year and is now Washington State law. One of the conditions was that we continue to study the area, monitor the effectiveness of the management plan, and release both the data and the analysis to state fisheries. A computer model is being developed which will facilitate making this study useful for analyzing other estuaries. A graduate student is doing a systematic sampling study of the sediment and animal gradients.

## SEQUOIA AND KINGS CANYON NATIONAL PARKS

### NATURAL FIRE FREQUENCY IN THE MIXED-CONIFER FOREST IN SEQUOIA AND KINGS CANYON NATIONAL PARKS SKC-N-27

INVESTIGATOR: Bruce M. Kilgore  
National Park Service

SUMMARY OF  
PROGRESS: No field work was carried out on this project in 1973. A manuscript summarizing the main findings and conclusions was drafted during the summer of 1973 with co-author Daniel Taylor. This manuscript is going through final stages of preparation and should be complete by mid-1974. Hopefully, it will be reviewed by late summer of 1974 and submitted for publication by fall of 1974. Previous results on this project were reported in the 1972 Annual Report of the Office of Natural Science.

# # #

### RESTORATION OF NATURAL ENVIRONMENT IN MIXED-CONIFER FOREST IN SEQUOIA AND KINGS CANYON NATIONAL PARKS SKC-N-26

INVESTIGATOR: Bruce M. Kilgore  
National Park Service

SUMMARY OF  
PROGRESS: No field work was undertaken during 1973. A paper on The Ecological Role of Fire on Sierran Conifer Forests: Its Application to National Park Management was published in *Quaternary Research* 3:496-513. In addition, a manuscript on Crown Fire Potential in a Sequoia Forest After Prescribed Burning was drafted with co-author Rodney W. Sando and received an unofficial professional review by 12 reviewers. This manuscript will be submitted early in 1974 for publication, possibly in *Forest Science*. The findings from this project were previously summarized in the 1972 Annual Report of the Office of Natural Science.

A COMPARISON OF THE ALGAL GROWTH POTENTIAL AND NUTRIENT  
LEVEL OF FOUR LAKES: HEATHER AND TAMARACK IN SEQUOIA PARK  
AND ARROWHEAD AND BIG BEAR IN SAN BERNARDINO MOUNTAINS  
SKC-N-36

INVESTIGATOR: Gary J. James  
University of California, Irvine

SUMMARY OF PROGRESS: On the basis of work completed to date, the following comments may be made concerning the water quality in Heather and Tamarack lakes. In spite of the relatively heavy use of Heather Lake as compared with Tamarack, neither lake appears to be substantially polluted. The experiments I have been conducting indicate that the water from both lakes is of high quality and the potential for aquatic plant growth is quite low. Since aquatic plants, particularly algae, require both phosphate and nitrate to sustain them, it can be presumed that neither lake has substantial amounts of these nutrients in the water. By comparison, the two lakes in the San Bernardino Mountains receive intensive human use and the water quality is very poor.

During the coming season, as the lakes are available for water collecting, I hope to continue the study. A second set of data is desired to compare with the original data. This information may indicate any trends which are occurring in the lakes as far as nutrient buildup is concerned. In addition to water collecting from the lakes, I also plan to obtain information about the physical features of the lakes being studied.

# # #

ECOLOGY OF GIANT SEQUOIAS  
SKC-N-1

INVESTIGATORS: Richard J. Hartesveldt H. Thomas Harvey )  
Howard Shellhammer Ronald E. Stecker) San Jose State University

SUMMARY OF PROGRESS: Readers are referred to contract reports of the research team from 1965 through 1972 for the details that are too extensive for this report. No formal field work has been undertaken by the team since 1971 except yearly seedling survival counts in the study areas. The number of surviving seedlings in the burn areas continues to drop every year. In 1973, there was considerable seedling loss due to limb fall during the winter and spring months.

# # #

SIERRA BIGHORN ECOLOGY  
SKC-N-3a

INVESTIGATORS: Maurice J. Zardus  
David J. Parsons

OBJECTIVES: To determine the current status of the Sierra bighorn in Sequoia and Kings Canyon national parks. An evaluation of current range conditions and potential impact of people, Tule elk, and other disturbances on the

population is also envisioned.

**METHODS:** Operations in 1973 were limited to a single trip to the Sawmill Pass area to evaluate potential study possibilities and the collection of observations accumulated by backcountry rangers.

**RESULTS:** A total of 23 sheep were sighted in the Sawmill Pass area in September, including one close observation of a herd of nine young rams. Signs were abundant in that region. Additional sightings were reported from Woods Lake, Gardiner Basin, Baxter Lake, and Sixty-Lakes Basin.

**PLANS FOR 1974:** It was decided that present resources and manpower in the park are insufficient to conduct the necessary studies. An outside investigator should be found to conduct a thorough evaluation of Bighorn range and habitat over a several year period. National Park Service personnel, without such assistance, will be able to do little more than continue with a hit and miss monitoring program dependent heavily on reported sightings by park visitors.

# # #

GEOLOGY OF KINGS CANYON NATIONAL PARK  
SKC-N-5a

**INVESTIGATOR:** James G. Moore  
U.S. Geological Survey

**SUMMARY OF PROGRESS:** Spent one month in the summer of 1973 mapping along the southern park boundary in the headwaters of Sugarloaf Creek, Ferguson Creek, and Deadman Canyon.

Published a description of a diagnostic fossil found in metamorphic rocks west of the park near Boyden Cave.

Prepared preliminary geologic road log of Highway 180 from Fresno to Cedar Grove.

# # #

CRYSTAL CAVE, SURVEY  
SKC-N-8

**INVESTIGATOR:** Thomas Rohrer

**SUMMARY OF PROGRESS:** As work progresses on a periodic basis, additional work seems to be added (needed). One added item is to verify the stream course and work on surface topography. My previous stream tracing has proven inconclusive.

DECOMPOSITION RATES OF MEADOW HERBAGE IN THE CENTRAL SIERRA NEVADA  
SKC-N-17b

INVESTIGATOR: Raymond D. Ratliff  
Pacific Southwest Forest and Range Experiment Station

SUMMARY OF PROGRESS: This study was started with the objective of developing indices to rates of decomposition in mountain meadows of the Sierra Nevada. Results being obtained are basic to testing two hypotheses: (1) a portion of the annual production of a meadow must be returned to the system for maintenance; and (2) the portion required to be returned for maintenance is equal to the portion which will decompose annually.

During September 1973 decomposition samples placed in September 1972 were recovered and new sets of samples were placed. Soil samples were collected from the 5 cm depth (depth of placement of subsurface samples), and have been analyzed for moisture and organic matter content. Herbage samples from 1972 have been processed to determine the standing crop and the ash content of the herbage. The decomposition samples are presently being processed to determine percentages of initial weight during the year.

SIGNIFICANT FINDINGS: Results thus far obtained are summarized in the following table.

Mean values for five factors in five meadows of  
Sequoia National Park

Factor	<u>Meadow</u> <sup>a</sup>				
	A	B	C	D	E
Sept., 72 standing crop (g/ft <sup>2</sup> )	4.20	18.56	12.26	43.42	21.14
% ash in 1972 herbage	4.98	7.63	9.86	14.56	9.95
Sept., 73 standing crop (g/ft <sup>2</sup> )	3.14	16.93	15.26	35.18	18.12
% soil moisture (5 cm depth)	2.75	89.67	23.57	105.86	208.64
% soil organic matter (5 cm depth)	12.06	33.77	6.75	37.20	69.83

<sup>a</sup>A = Short-hair sedge (*Carex exserta*), B = Shorthair (*Calamagrostis breweri*) of lake shore, C = Shorthair of large open meadow, D = Tufted hairgrass (*Deschampsia caespitosa*), E = broad-leaf carex-peat (*Carex rostrata*).

RECOMMENDATIONS: The study should and will proceed as planned. However, in order to reduce travel time to and from the study area, we request the National Park Service to provide support in the form of helicopter transport of men and equipment. This support should amount to two trips (one in and one out) per year.

We plan to publish first-year results as a Station Research Note shortly after laboratory processing of decomposition samples is completed. A final publication of results is planned by June 1976.

DEER ECOLOGY (DEER AND RANGE PROBLEMS IN HIGH USE AREAS)  
SKC-N-18

INVESTIGATOR: Maurice J. Zardus  
Sequoia and Kings Canyon National Parks

SUMMARY OF PROGRESS: Primarily management, this program has included only modest amounts of research to date.

1. No research was carried on in 1973.
2. Herd composition counts and partial censusing have led to preliminary conclusions that deer herd size is declining.
3. Annual herd composition counts will be continued.
4. Autopsies and food studies will be made on road kills when opportunity exists.
5. Pellet-count transects have been used and will continue to be used for census numbers.

# # #

THE ROLE OF FIRE IN CHAPARRAL  
SKC-N-28a

INVESTIGATOR: David J. Parsons  
Sequoia and Kings Canyon National Parks

OBJECTIVES: To study the role of fire in the chaparral communities of the lower elevation foothill regions of Sequoia National Park. Information is needed both on the historical frequency of fire in these areas and on understanding the ecological effects of fire on the plant and animal communities involved. The ultimate objective is to provide the background information needed to restore fire to its natural role in this community type.

METHODS: Historical records will be examined to help understand the past frequency of fires in this community type. Field studies will be aimed at sampling vegetative characters of different-aged stands in an attempt to relate community structure to fire frequency. Sampling will also aim at understanding the role of fire in creating the vegetative mosaic found in the foothill regions.

RESULTS: To date, only preliminary attempts at accumulating literature and historical records have been made.

PLANS FOR 1974: A thorough literature and historical survey will be conducted. Field plots will be established in different-aged chaparral communities as determined by park fire records and data gathered on species composition and above ground biomass. An attempt will be made to evaluate possible methods of dating past fires.

Publications:

Publications are anticipated on the historical frequency and role of fire in this region.

BLACK BEAR ECOLOGY  
SKC-N-31

INVESTIGATOR: Harold E. Basey  
Sequoia and Kings Canyon National Parks

SUMMARY OF No progress was made this year.  
PROGRESS: Future activities will depend upon development of improved photographic  
sampling techniques.

Some financial support will be required to pursue the studies as needed. A request to this effect will follow shortly.

# # #

LILBURN CAVE AND THE KARST OF REDWOOD CANYON  
SKC-N-33

INVESTIGATOR: Stanley Ulfeldt  
Lilburn Cave Research Project Committee of the Institute for Special  
Ecological Studies and National Speleological Society

SUMMARY OF During 1973, 17 weekend work trips were made to the cave area. Because  
PROGRESS: the answers to several important questions on the genesis and dynamics  
of the cave system depends on knowledge of the nature of cave between  
the upstream end of known cave and the sinkholes where the water enters the system, most  
of our time this year was spent trying to find an entrance into this section of the cave  
system. On 10 November 1973 we were rewarded with what may be success; after digging  
about 100 ft of fill from a cave passage that opened to the surface, we broke through into  
an air-filled cave. The passages are small and several are not yet explored. The  
location is 150 yards downstream from the main sink of Redwood Creek at a depth of 200 ft  
and it offers good prospects of reaching the main underground stream passage.

*Survey and Exploration:* About 2500 ft of passage was surveyed in Lilburn this season.  
Work has begun on a highly accurate survey to the South Seas, the downstream end of the  
cave, to Big Spring, the resurgence of the cave system.

*Hydrology and Geology:* Marty Sara, a practicing geologist and graduate student at  
University of Southern California, began work on his masters project on the hydrology  
and geochemistry of the Lilburn Cave system. This year he completed field work on a  
reconnaissance of the karst area.

*Future:* More time may be required to complete our studies if a large amount of new  
cave is found. The new area has potential for as much or more passage as is known  
already in Lilburn proper. Luther Perry, a member of our group and an Assistant Professor  
at California State University at Hayward, has applied to the National Science Foundation  
for a grant to conduct a geographical field exercise with the purpose of producing a  
detailed, accurate base map of the karst area of Redwood Canyon

VEGETATION PATTERN WITHIN A MIXED CONIFER-GIANT SEQUOIA FOREST ECOSYSTEM:  
ITS CAUSATIVE FACTORS AND SUCCESSIONAL IMPLICATIONS

SKC-N-34

INVESTIGATOR: Thomas M. Bonnicksen  
University of Claifornia

SUMMARY OF PROGRESS: Vegetation within mixed conifer- giant sequoia forest ecosystem is highly contagious. Statistical significance was shown for all populations studied and mean patch sizes were determined. Fire was considered the most important causal factor for the pattern of vegetation exhibited on the study area and within this forest type generally. The findings of the research suggest that the steady-state condition of this ecosystem is extremely dynamic with respect to the pattern and species composition of vegetation subjected to a periodic fire regime. Finally, the pattern represented is visually recognizable and managerial inputs can be used to simulate the primeval dynamic, steady-state of the ecosystem while simultaneously reducing the probability of catastrophic fires.

# # #

BLACK OAK FIRE ECOLOGY

SKC-N-37

INVESTIGATOR: James Sellers  
Kingsburg High School

SUMMARY OF PROGRESS: *Post-burn results:* (one year after the burn in plots 1 and 4)  
*Trees:* No change in tree composition was noted in plots 2, 3, and 4. In plot 1 a small (8") incense cedar died. This tree was near the hottest candeling in white fir thickets.

*Saplings:* The abundance of all species remained the same as the spring data in the control plots. In the burned plots the following changes were noted: live oak increased by one in plot 1, live oak decreased by one in plot 4 (this was the only sapling of live oak previously recorded for plot 4), black oak decreased by three in plot 4 (show evidence of stump sprouting), and white fir decreased over 50% since the spring data.

*Seedlings:* A decrease in all plots except black oak and live oak. Ponderosa pine decreased 96%, incense cedar decreased 96%, white fir decreased 94%, sugar pine decreased 91%, and live oak showed an overall decrease of 20%. Live oak seedlings in plot 4 increased 60% and black oak increased 480% overall with the major increase in an unburned plot. Three black oak seedlings were a result of stump sprouting of dead black oak saplings.

*Cover:* Herbaceous cover increased an average of 1% in the burned plots (plots 1 and 4), 6% in unburned plot 3, and decreased 4% in unburned plot 2.

Litter increased in plots 1 and 2 while the amount of bare rock/soil decreased accordingly. Litter decreased in plots 3 and 4 while bare rock/soil increased, but to a lesser extent.

*Litter and Duff:* Litter and duff depths have increased an average of 1.4 cm since the fire, ranging from -0.2 cm to 2.0 cm.

DISCUSSION: An incense cedar in a burned plot was dead this fall and the cause may be directly attributed to the fire. After the fire, it was noted that the foliage was browned due to the convection currents that swept up the tree during the fire. The cedar was in an area with many white fir saplings that allowed the fire to candle. A number of other trees also showed damage from convection currents but none have died. Several of the black oaks burned inside for most of the evening but to this date all are alive. So far they have been resistant to the effects of the fire.

Most of the black oak saplings in plot 4 that had been burned showed evidence of stump sprouting. The stump sprouts were then counted as seedlings (perhaps unfairly since the roots are already well established). These stump sprouts showed evidence of having been browsed by deer. Deer pellets were also found at the site. White fir saplings declined greatly, probably because the limited foliage that remained after the fire was insufficient to support the saplings through the hot summer months. Since no change was observed in the control plots, the data may be a result of the fire.

The reduction in most of the seedling counts indicate that most of the spring-germinated seedlings cannot survive through the summer months. The oak seems to have an advantage in that the roots may be deep and some of the food and moisture are available from the acorn.

The change in herbaceous cover seems to show no clear-cut change between the burned and control plots.

The litter and duff decreased in burned plot 1 while increasing in all other plots. There are few large pine trees in plot 1 and with the decrease in white fir saplings not as much litter would be expected to accumulate. The decrease in plot 1 may be a result of compaction or sampling technique.

PLANS FOR 1974: We plan on taking measurements in the spring and fall of 1974 to compare with data already taken.

# # #

#### ISOTOPIC STUDIES ON SPELEOTHEMS, CAVE AND METEORIC WATERS SKC-N-38

INVESTIGATOR: Peter Thompson  
California Institute of Technology

SUMMARY OF PROGRESS: A search is being conducted for a cave (or caves) where speleothems (cave deposited travertines) are being deposited in isotopic equilibrium with cave seepage waters. The isotope ratios of interest are  $O^{18}/O^{16}$  and  $C^{13}/C^{12}$ . The objective is to calibrate a "speleothem geothermometer" by studying present-day processes and isotopic fractionations so that eventually the extent of past Californian climate changes can be measured from fossil speleothems.

Crystal Cave and Soldiers Cave may be suitable for these experiments. A prerequisite is that the temperature of the cave(s) must be constant but it will be a number of months before this can be established. Initial temperature measurements indicate that seasonal variations may be significant because the temperature in Crystal Cave in November and December was 8.3 and 8.6°C, respectively, and the mean annual temperature (mat) (the temperature the cave should assume) should be about 11°C, based on interpolation of climate data from Ash Mountain and Lodgepole stations. However, it is not unusual for caves to be slightly below mat. If it is found that there are significant temperature changes in either cave, then the measurements will have to be discontinued and alternative sites found.

A program was started to collect meteoric precipitation from Ash Mountain and Lodgepole stations in order to correlate the isotopic composition of cave waters with local precipitation. This will enable me to determine during which part of the year speleothems "grow."

Some preliminary isotopic measurements have been made, but they will be reported later.

# # #

#### ANATOMICAL AND BIOLOGICAL STUDY OF THE MONOTROPOIDESE (ERICACEAE)

INVESTIGATOR: Gary D. Wallace  
Claremont Graduate School

SUMMARY OF PROGRESS: Material for anatomical studies has been gathered. Further information, over several years, on pollination establishment, local distribution, and variability over the years is required. Assistance in locating out-of-the-way populations of these plants would be appreciated. Care should be taken to protect populations of *Pityopus californicus* and *Hemitomes congestum* which are very rare in the Sierra. The location I was studying in Whittaker Forest was burned over.

# # #

#### THE INFLUENCE OF FIRE ON THE NUTRIENT STATUS OF GIANT SEQUOIA FOREST SOILS SKC-N-35

INVESTIGATORS: Philip W. Rundel )  
Theodore V. St. John) University of California, Irvine

PURPOSE: The role of fire in giant sequoia regeneration and the mechanisms by which fire favors the reproduction of this species is now well documented. These effects are brought about primarily by burning away forest floor organic material and competing plant species and by the effect of heat in releasing seed from cones still attached to the trees (Kilgore 1970). It has been postulated that fire plays an additional role in releasing the mineral nutrients from dead organic matter, but definitive studies in giant sequoia and similar situations are lacking. Previous relevant studies (Heyward and Barnette 1934) are not of such a design as to directly answer the question of whether periodic burning releases nutrients in a form available to sequoia seedlings.

The purpose of this project is to address this question: Does the fire make available an improved nutrient environment for the seedling? The project was carried out in two major phases: a sampling and chemical analysis program designed to detect a difference in nutrient levels in actual burned sites in sequoia groves, and a greenhouse experiment designed to determine the requirements of *Sequoiadendron* seedlings.

SUMMARY OF PROGRESS: Field sampling and sample handling were completed during July and August 1972. Chemical analyses of the soil samples are still underway; nitrogen, carbon, pH, bulk density, fraction greater than mm, percent water, and cation exchange capacity tests are completed, while phosphorus, calcium, magnesium, and potassium determinations are still in progress. Greenhouse experiments have been going on for some months, but repeated difficulties with nutrient solutions and microorganism contamination and parasitic fungi may limit the usefulness of this information.

Of the tests completed so far, sample sizes seem to be more than adequate (total sample size was 100 in most cases) and the results of early statistical analyses show much promise for the success of at least the field portion of the project.

## SHENANDOAH NATIONAL PARK

### GROUND-WATER RESOURCES STUDY AND DEVELOPMENT SHEN-N-6

INVESTIGATOR: James L. Calver  
Virginia Division of Mineral Resources

SUMMARY OF It was stated in the Investigator's Annual Report, dated 1 December 1972,  
PROGRESS: that the final report on ground-water supplies in Shenandoah National  
Park was to be published by 31 December 1972. Printing and corrections  
delayed the availability of this publication by 2.5 months.

On 14 March 1973, copies of the report, entitled Development of ground-water supplies in Shenandoah National Park, Virginia, were delivered to the Park Superintendent at park headquarters, Luray, Virginia. With the submission of that report, this study was concluded.

# # #

### IMPACT OF EXOTIC PLANTS ON THE ECOSYSTEM SHEN-N-10

INVESTIGATOR: Paul R. Lee, II  
Harrisonburg, Va.

SUMMARY OF Studies done with the two most prominent exotic species: *Lonicera*  
PROGRESS: *japonica* Thunb., and *Ailanthus altissima* (Mill.) Swingle. Low-light  
intensity and increasing elevation were shown to be the most significant  
limiting factors to the growth of both species. Neither species appears to be invading  
already established forested areas. Control measures do not appear necessary except  
possibly in the case of vista management.

ECOLOGY AND POPULATION DYNAMICS OF THE BLACK BEAR  
SHEN-N-13

INVESTIGATOR: Jack W. Raybourne  
Virginia Commission of Game & Inland Fisheries

SUMMARY OF A total of 76 black bears have been captured, immobilized, ear-tagged, and  
PROGRESS: tattooed for identification on the Shenandoah National Park. In addition,  
records were recorded on body weight, body measurements, reproductive  
status, and estimated age and a first upper premolar was extracted from each animal for  
later laboratory cross-sectioning and microscopic age determination.

SIGNIFICANT Data are not sufficient to produce significant findings to date.  
FINDINGS:

RECOMMENDATIONS: Plans should be continued as scheduled to evaluate cub production in  
spring 1974, continued live-trapping and tagging and examination of  
retrapped animals for formulation of population estimates and movement patterns. Live-  
trapping operations may require expansion or modification to include use of the Aldrich  
foot snare should efforts to recapture previously marked animals in sufficient numbers  
fail.

Assistance rendered by numerous National Park Service personnel during this summer's  
trapping operation was highly cooperative and most gratifying.

Plans are to resume trapping and tagging operations in April 1974 and to continue into  
early fall 1974, dependent upon trapping success.

# # #

LOCATION AND SAMPLING OF UNUSUAL RHODODENDRON

INVESTIGATOR: F. W. Shield

SUMMARY OF I have located albino varieties of *Rhododendron catawbiense* but have not  
PROGRESS: taken any plants, cuttings, or seed.

## SOUTH FLORIDA

### SUPERINTENDENT'S ANNUAL RESEARCH REPORT

RESEARCH ACCOMPLISHMENTS AND ACTIVITIES: The year 1973 was one of increased volume and diversity of activity, shifting of emphasis, and of continued growth and depth. We began with a basic budget exceeding \$150,000; added \$11,000 from BSF&W for Cape Sable Sparrow studies, almost \$44,000 from the South Florida Project for completion of a combined South Florida Environmental Report, in addition to wading bird surveys around the Big Cypress Jetport, and water quality monitoring in Biscayne National Monument. An even more significant step forward was taken when Region made up to \$30,000 available for studies to determine the relationship between water releases into the Shark Slough through the S-12 structures, slough drying rates, resulting concentration of fish, and the availability of fish upon the reproductive success of Wood Storks nesting in Everglades National Park.

Other studies continued through the year included, but were not limited to, Bald Eagle studies, tern studies, crocodile and alligator studies, sport and commercial fishery statistical studies, studies of Ospreys, Short-tailed Hawks, sea turtles, lobsters, wading birds, and Florida Bay fisheries ecology, etc., were successfully carried on. Several projects were brought to a successful conclusion, with submission of draft reports for review and subsequent publication.

The Florida Bay fisheries ecology programs were activated by filling the position vacated by John Bellinger with the hiring early in the year of Thomas Schmidt. The study group acquired Gary Davis through transfer from the Resource Management program. Dr. Gary Hendrix was brought onto the staff to continue studies in Biscayne National Monument, but ended up representing NPS on the local RALI program, and is currently assigned to the task force editing and seeing the final report through publication. The study group's technical support left for continued educational pursuits, making it necessary to hire and train new technicians.

There were a number of volunteers in the park (VIP's) who spent time working in association with various staff principal investigators. VIP's conducted several short-term but often highly productive natural resource studies. One of these, in Biscayne National Monument, involved an energy flow study in Old Rhodes Key Lagoon. Robert Holm, a Ph.D. candidate at Northwestern University, spent 6 months of last year conducting field studies in the lagoon and plans an additional 6 months of the coming year as a follow-up effort. Mr. Holm has been conducting his studies under the guidance of the Resources Management Coordinator.

Miss Debbie White, from the University of Texas, Austin, Texas, assisted in the spiny lobster population study at Fort Jefferson National Monument as a VIP for 3 weeks in April 1973. She helped measure, tag, and release lobsters and conducted population surveys using SCUBA.

Aside from the usual, routine research efforts by the group this year, several noteworthy projects were undertaken. These included radio tracking of Florida Bay crocodiles and an extensive lobster-tagging project.

Other accomplishments included placing the trailer office/laboratory in operation, acquisition of an airboat, van, and three skiffs, several dredge and fill project investigations and permit application review and comment, investigation of fish and bird kills, Environmental Impact Statement review and comments, the Morman and Pavillion keys investigation, the Cross Florida Barge Canal case, and review and comments of the South Florida Environmental Project reports. In general, while there was a phase down of activity in Biscayne National Monument, studies were expanded at Fort Jefferson National Monument, and particular emphasis was placed on the resolution of resources management problems in Everglades National Park.

**PUBLIC RELATIONS:** The majority of public contacts made by members of the study group were through requests for collecting permits, lectures requested by visiting university and high school ecology classes, answering of telephone requests for natural resource information, and providing basic resource information to conservation writers, news broadcasters, newspapers, magazines, and periodicals.

Collecting permits were issued to qualified individuals, students, volunteers in the park, and others who could provide useful information in return. Study group staff answered letters of inquiry from around the world as well as the Americas, and provided leading opinions, technical procedures, as well as sending catalogs for supplies and equipment, technical bulletins, and other publications. Staff members gave lectures to advanced university classes, high schools, and even elementary schools. We reviewed and edited manuscripts for scientific journals, popular magazines, news letters, and TV or radio program material. Study group staff members were called upon to brief the Interpretive and Ranger divisions on matters of the park's natural resources, management objectives, and research methods and goals. We participated in conservation organizations and gave guidance to and assisted in providing technical expertise to same as well as contributing to program activities.

**COOPERATION WITH OTHER AGENCIES:** Study group personnel participated on a give and take basis with numerous Federal, state, and local governmental agencies. Program and information exchange was carried out in cooperation with U.S. Geological Survey, Bureau of Sport Fisheries and Wildlife, National Oceanic and Atmospheric Administration, National Aeronautic and Space Administration, the Department of Agriculture's Entomological Research Center, Agricultural Research Service, U.S. Forest Service, and the Government Accounting Office. State agencies included State Game and Freshwater Fish Commission, State Division of Recreation and Parks, Miami Dade Junior College, South Florida Regional Planning Council, Secretary of State's Office, Internal Improvement Fund Board, Marine Patrol, Florida State Museum, Department of Natural Resources, and the State Pollution Control Department.

Local agencies dealt with included Dade County Parks Department, Dade County Pollution Control, Monroe County Zoning, and several others. Conservation organizations worked with included the Sierra Club, Audubon Society, and Izaak Walton League. Several universities had cooperative agreements with our personnel including the University of Virginia, University of Miami, University of Florida, Florida State, University of South Florida, Glassboro State College (N.J.), Virginia Polytechnic Institute, and Northwestern University.

**ACCOMPLISHMENT OF GOALS:** Goals are established on a fiscal year basis, with progress or accomplishments reported at the end of the calendar year and again at the close of the fiscal year. Hence, reporting of goals at this time often finds us with 50% or less accomplishment.

Goals promulgated by the Studies Group (several qualifying as objectives rather than goals) included: revision and updating of the Everglades N.P. Resources Management Plan and Natural Sciences Study Plans; efforts to fully equip and provide support for the study group in the form of field and laboratory equipment and supplies; efforts to provide a more uniform, efficient, and effective means of handling acquired data, reporting of findings, inventorying equipment and supplies, managing funds, and caring for and using equipment, etc.; development of a comprehensive South Florida National Park Service, Natural Sciences Study Plan, and implementation of a systematized study approach based on long-term goals and priority of information needs; and finally a plan to acquire the needed funding and scientific staff to accomplish the previous objectives. Short-term (annual) goals included accomplishment of such tasks as completed manuscripts, acquisition of certain pieces of information through basic data acquisition monitoring of in-park activities, i.e., commercial and sport fishery harvests, evaluations of prescribed burning effects, and a continual level of study on specific projects.

An overview reveals that we have made significant progress on some fronts, notably in the initiation of studies in Florida Bay fisheries ecology, the prescribed burning studies, and with respect to routine acquisition and analysis of sport and commercial fishery harvest data in Florida Bay. An expected level of progress was made with respect to

publication of manuscripts--which seems always to be slow and painful process. The greatest shortcomings have been in development of a unified Natural Sciences Study Plan, and in reinstating studies in Biscayne National Monument. Recent emphasis, however, on means to further these ends should prove fruitful.

## WALNUT CANYON NATIONAL MONUMENT

### TURKEY VULTURE (*CATHARTES AURA*) POPULATION STUDY VERTEBRATE FAUNAL STUDY FOREST COMPOSITON STUDY

INVESTIGATOR: Mike Salmonson

**SUMMARY OF PROGRESS:** *Turkey Vulture (Cathartes aura) Population Study:* Turkey Vultures are the most readily seen birds in the monument and, as such, cause considerable interest among the visitors. The summer resident population of breeding Turkey Vultures has declined by about 50% since the early 1960s. This study is attempting to determine the cause of the decline and, if appropriate, will recomend steps to be taken to end the decline. Foraging ranges, food sources, and various aspects of the breeding biology of the vultures are being studied. So far, only preliminary work has been done and probably two summers will be required to complete the study. If the results are significant, they will be submitted to an appropriate journal for publication.

*Vertebrate Faunal Study:* This project was started in 1972 and is continuing at the present time. Objectives are to determine as nearly as possible what species of vertebrates are found in the monument and to build up a collection of those vertebrates for use in interpretive and scientific activities. To date, three species of birds, one reptile species, and eight species of mammals previously unreported in the monument have been identified. Efforts during the summer of 1973 concentrated on collecting and identifying members of the monument's bat population.

*Forest Composition Study:* This is a detailed study of the species compositions of the three major forest types found in the monument. Evaluations of the importance of each species within a particular forest type, and of the same species in different forest types, are being made using relative and absolute height, age, density, frequency, and dominance data. Results are to be used in resources management activities and in future scientific studies where appropriate. At present, the field work for the study is about 85% completed and should be finished by the summer of 1974.

# UNIVERSITY OF WASHINGTON

## COOPERATIVE PARK STUDIES

INVESTIGATORS: Donald R. Field)  
Garret Smathers) College of Forest Resources  
A. R. Weisbrod )

### SUMMARY OF PROGRESS:

#### 1. Research Projects--Biology

See:

Mount Rainier National Park  
Studies on the effects of elk on the ecosystems within Mt. Rainier National Park  
Charles H. Driver, MORA-N-4a

San Juan Island National Historical Park  
Estuarine studies and population dynamics of clams.  
Vincent F. Gallucci

Olympic National Park  
Vegetation dynamics and human trampling.  
Garrett A. Smathers and Edward P. Schreiner, PNWR-N-1

San Juan Island National Historical Park  
The biology of the rabbit *Oryctolagus cuniculus* in San Juan National Historical Park  
and vicinity.  
A. R. Weisbrod and W. Frederick Stevens, SAJH-N-1

Glacier Bay National Monument  
The breeding ecology of colonial sea birds on the Marble Islands of Glacier Bay, Alaska.  
A. R. Weisbrod and Samuel M. Patten, Jr., GLBA-N-16

Glacier Bay National Monument  
Preliminary biological investigations of the Lituya Bay ice-free regions.  
A. R. Weisbrod, GLBA-N-17

#### 2. Research Projects--Sociology

A. Sociological dimensions of leisure involvement in water-based recreation.  
(Investigator: Donald R. Field, University of Washington)

This project was designed as a baseline study to identify essential sociological dimensions of participation in water-based activities. Several objectives were established for the study. They were:

To identify social groups participating in water-based recreation, as well as the social and economic characteristics of user-nonuser populations; to identify variation among social groups participating in specific water-based recreation activities; to determine in what manner involvement in specific water-based recreation is complementary or divergent from involvement in other outdoor leisure pursuits; to compare similarities and differences among water-based recreational users and nonusers in terms of involvement in general patterns of leisure behavior.

In general the objectives have been attained, but the emphasis placed upon each objective has varied since the inception of the project. Originally, equal attention was

to have been given to each. As the project progressed, it became clear that while data about user-nonuser populations were scarce, the general relationship of differences in terms of socio-demographic characteristics noted elsewhere continued to be valid. A more fundamental question emerged. With the wealth of data regarding participation, why were predictive models of recreational demand misleading? Therefore, a decision was made to shift the current research emphasis toward a systematic analysis of those factors associated with participation in a selected set of water-based activities wherein the results would have meaning for improving the predictive capabilities of models designed to measure recreation demand. Consequently, the latter approach is more methodological in nature, focusing on particular aspects of original objectives.

We suggested in our project proposal that much of the work undertaken in recreational activity research was incomplete. Assessments of who participates through an examination of social, economic, or demographic characteristics are commonplace. The same may be said for much research focusing on the relationship between participants and water-based recreation. Yet these factors by themselves are insufficient to delineate several key dimensions associated with participation (Burdge and Field 1972; Meyersohn 1969).

Traditional demand studies, so popular with state agencies responsible for recreational planning, have this format. Area-specific analyses predominate as another type of study relying on characteristics of the population, the collation of which yields fragmental and sketchy conclusions.

Unfortunately, the predictive capabilities have been less than desired, partly because of an underlying assumption that activities are place-specific and-or facilities are conducive to a limited range of human involvement. Avoidance of such error has guided our theoretical and methodological approach in this study.

We have placed research emphasis upon one sociological variable throughout the study, namely, the social group. Participation in leisure occurs most often with others, not alone. Therefore, the human action which occurs in leisure settings is reflective of membership in a social group. In terms of participation we argue it is more important to know how people organize themselves to play, rather than to know the activity in which participation takes place. Recreation activities facilitate leisure participation; they are not the basis for participation. These points have been ignored in the bulk of recreation research reports in the past.

By focusing on the social group we do not mean to imply that this variable is the only one which should be added to customary socio-demographic characteristics when attempting to improve the predictability and reliability of recreation-demand models. Investigation of the role of the social group in determining leisure behavior is only a beginning. Other sociological variables must be considered in the future. In the context of this study what we have done is to demonstrate statistically the viability of the social group variable, in conjunction with alternative methodological approaches for assessing differential participation in a common set of water-based recreation activities.

B. Community conflict and adaptation - An examination of community response to change in natural resource policy and management strategies (Investigators: Donald R. Field and Joseph T. O'Leary, University of Washington)

The introduction of a National Park is generally associated with a variety of claims that assert a wise assortment of impacts on local communities nearby. Economic impact studies prepared for the National Park Service generally indicated the creation of positive effects. But studies detailing the social consequences of introduction have been sorely lacking. Studies of the impact of large installations and the small community in transition in the sociological literature have suggested a more complex web of interactions develop as a result of the change, many of which initiate or reinforce institutional inadequacies in the proximate communities. Since the National Park Service has expressed significant interest in maintaining close liaison with the local communities for planning and development integration, a fuller knowledge of both social and economic consequences is essential.

In 1968 the North Cascades National Park was formed. It is surrounded by a number of

small communities whose employment base is related to commercial timber production and recreation, and who tended to view the introduction negatively. Previous studies of large installation impact have indicated that the period from 5 to 7 years after introduction appears to characterize a time span when many of the constraints for the future of the community environment are established. Therefore, an investigation of a community close-by the park seemed especially appropriate and necessary at this time to gather information on the social dimensions of change and the consequences for local institutions created.

In November 1972, a search was initiated to choose a community for investigation near the park. By March 1973, the community had been chosen. At this point, I moved into the community for a 6-month period, beginning examination to discover how the town and its members were affected by the park introduction. ("I" refers to the Graduate Research Assistant.)

Using participant observation, a mail questionnaire, and a survey of historical information, data collection was completed by the end of October 1973. Data analysis and a preparation of written material were begun in November 1973 and are presently continuing.

It seems clear even at this early stage that redefinitions associated with the use of natural resources are dealt with differentially within the community. To the extent that institutional inadequacies appear stemming from a park introduction, this has a potential to create problems for both local and nonlocal (tourists) participants in the town, and for the National Park Service that has a growing need to interact closely with these local areas. It is hoped that the results of this research will define some of these problem areas, and provide useful guidelines for future changes that may occur.

C. North Pacific Border Study: A survey of park going patterns in the Pacific Northwest. (Investigator: Donald R. Field)

The North Pacific Border Study is an ongoing regional investigation of leisure behavior. The purpose is to provide information on visitor publics to managers of areas in the National Park system. The investigation emerges from a belief that many methodological approaches to the study of leisure heretofore have been incomplete.

Traditional activity research has relied upon social aggregate variables such as occupation, income, education, age, and marital status, almost entirely as a basis to predict demand for given activities. This is especially true for many studies completed on specific recreational sites where only participants are considered. However, once nonparticipants have been eliminated from consideration in the analysis, the major source of statistical difference measured by social aggregate variables has been removed resulting in the failure of these variables alone to explain participation. An analysis strategy is proposed in which a social group variable might be employed in conjunction with social aggregate variables to enhance the measurement of participation in leisure activities. Emphasis has been placed upon utilizing a new analysis approach for understanding park-going patterns in the Pacific Northwest Region.

D. Photogrammetry Study: A test of the feasibility of using remote-sensing techniques as nonreactive research tools in outdoor recreation. (Investigators: Donald R. Field and Peter M. Harvard)

The purpose of this research is to develop a methodology by employing remote-sensing techniques to acquire data about human use patterns in National Parks of the Pacific Northwest Region. Traditional aerial photographic techniques have rarely been applied in this type of problem, either independently or from a sociological perspective. Modification of existing techniques (i.e., using larger scales, specific time frames, pre-selected ground areas) should be adequate to provide this data at reasonable cost/benefit ratios.

Specific investigations will include: determination of approximate age/sex classes to define group status (family, affinity, individual), accurate measurement of spacing between and among these groups to determine "zones" of occupancy, examination of such zonation for patterning by activity or affinity group, interpenetration of zones, determination of activities (swimming, games, sitting, etc.) density gradients with respect to access points and amenities (windbreaks, privacy, sanitary facilities, picnic tables, etc.)

Aerial photography can never provide all of the data required. "Ground truth" will be provided by field studies, survey, and various observation techniques. The photographs will provide one frozen moment for checking field notes. However, it is anticipated that they will add a useful perspective of their own, or in conjunction with other accepted data acquisition techniques. Initial work will include a review of the literature and examination of photographs from 3 day-use areas, flown on Labor Day 1973. Specific techniques developed at this stage will determine the timing, scale, and emulsion (color or black and white) of the next stage. Initially, a water-oriented area will be used because of the relative openness of the site, but it is hoped to eventually compare this with an inland site.

The ultimate goal is to provide guidance in the use of aerial photographs for researchers interested in behavioral data and to test the validity of this technique for such purposes. Data produced from aerial photographs (in other fields) are capable of rigorous statistical examination. We anticipate undertaking a statistical analysis of the photographs presently available.

E. Backcountry use patterns in North Cascades and Mt. Rainier National Parks. (Investigators: Donald R. Field and Robert Flewelling, University of Washington)

A major project undertaken this year has been the computerization of information contained on National Park Service backcountry use permits. Copies of permits issued to people camping in Mt. Rainier and North Cascade National parks have been sent to the University of Washington for data processing. Much time this summer was spent on coding the North Cascades permits in a format suitable for keypunching. Hopefully, next year's permits will be uniform so that direct keypunching can be done from the permits.

The next step required was to convert the data into a form which could easily be utilized by a wide variety of statistical descriptions and procedures. Such a conversion program was developed for both data sets, which are now in an expanded format on tape, easily utilized by all standard statistical procedures.

After this summer's permits had all been coded, keypunched, and copied onto tape in converted format, descriptive information tables of permit information were run. Tables generated show amount of usage across time, amount of usage in various park areas, and descriptions of camping parties and origins. Tables were produced for each month as well as for the entire season.

These tables are currently being mailed to the respective National Park headquarters. Along with tables, a report containing explanations of the tables and an overview of what other types of information and analysis are available has been prepared. The current tables contain a good deal of general information which should be of great use in anticipating future usage and how to plan effectively for it. The retrieval of more specific information and more specific analysis of it is almost unlimited in its possibilities, and will be carried out upon request from National Park Service people.

By summer of 1974, we plan to have developed one large master computer program which will generate all the tables regularly needed on a single run. A method of efficiently handling a continuous supply of incoming permits is being developed, and it is hopeful that output of information will have a turnaround time of 2 weeks or less.

F. Interpretation for the handicapped. (Investigators: Donald R. Field, Grant W. Sharpe, and Jacque Beechel)

During 1973, Jacque Beechel has been investigating interpretive trails designed for use by people who are deaf, blind, mentally retarded, or who have ambulatory limitations. The objectives of the investigation are: (a) to determine the needs of handicapped persons; (b) to determine what has been done in the area of interpretive trails for handicapped persons; (c) to determine the successes and/or failures of such trails; (d) to develop design guidelines for such trails; and (e) to compile a directory of interpretive trails in the United States that accommodate handicapped persons.

The investigation has consisted of: a literature review, consultations with handicapped persons, consultants with people involved in the rehabilitation of handicapped persons,

development and administration of a questionnaire for managers of existing interpretive trails in the United States for handicapped persons, and traveling throughout the United States to view, firsthand, a representative sample of such trails.

Results of the investigation indicate: (a) interest in what interpretive trails can provide is the same in the handicapped portion of the U.S. population as it is in the nonhandicapped portion, but disproportionately fewer efforts have been made to provide accommodations for handicapped persons; and (b) managers of recreation lands are interested in accommodating handicapped persons but no guidelines are available.

Ms. Beechel is presently involved with the preparation of a Master's thesis that will incorporate the previously stated objectives.

G. Survey on desirable preparation and career development of interpretive personnel. (Investigators: J. Alan Wagar, Donald R. Field, and Juan Oltremari)

The objectives of the current study were to prepare a socio-demographic profile, identify characteristics of college education, type of in-service training, and work experience of the currently recruited interpretive personnel. An 11-page questionnaire was distributed between July and August 1973 to all personnel (permanent and seasonal) working in areas of the Pacific Northwest Region of the National Park Service, and to personnel from all nine regions of the U.S. Forest Service.

Response to the questionnaire reached 73.7% in the National Park Service, and 85.6% in the Forest Service by the end of October 1973.

Among the many individual items, respondents were asked to identify degrees obtained at college, number of courses taken in pertinent disciplines, desired college preparation, type of in-service training, media used for recruitment, chronology of positions in resource management organizations, experiences they consider important for interpretation, and motivation of interpretive work.

The data obtained were computer processed during November and December 1973. The findings then will be summarized in a final report by March 1974.

Results will be of greatest use within the National Park Service, the Forest Service, and to the educational units preparing people for employment as interpreters.

H. Children's interpretation: Developing appropriate formats. (Investigators: Donald R. Field and Gary Machlis)

Any fruitful approach to children's interpretation must be based on a sound conceptual framework of children's behavior. We began by asking the question: what affects the way children learn? Broadly speaking, three main concepts became apparent: (1) limitations--physical environment, emotional and mental development, social limitations; (2) concerns--what really interests children? and (3) motivations--what triggers learning behavior?

Next, general approaches to specific interpretive programs were developed. These interpretive "keys" offer park planners options in the type of program of interpretation. The three major interpretive keys are: (1) Action--full experiences, using several senses and giving children chances to participate; (2) fantasy--involving children's powerful imaginations in interpreting things around them; and (3) instruction--offering information and how-to-do-it material of value to the children.

A practical application is now being attempted. We are developing a children's interpretive program for Fort Vancouver National Historical Site that hopefully will be grounded on the behavioral concepts and which will utilize all three interpretive keys. Work includes an historical activity book, a film strip, and instructional aids for teachers. All materials will be in use around March of 1974.

### 3. Invited Papers and Publications:

- Weisbrod, A. R., D. R. Cline, and J. M. Kauffmann. 1973. Noatak National Ecological Range (proposed): Draft Environmental Statement. USNPS - USFWS Report to the Secretary of the Interior. June 1973. 140 p.
- Weisbrod, A. R. 1973. Noatak National Ecological Range (proposed): A Master Plan. USNPS - USFWS Report to the Secretary of the Interior. June 1973. 49 p.
- Weisbrod, A. R., and S. M. Patten, Jr. In press. Interbreeding Between Two Species of Gulls (*Larus*) in Southeastern Alaska. *The Condor*. Accepted, June 1973.
- Weisbrod, A. R., and W. F. Stevens. In press. The Skylark in Washington. *The Auk*. Accepted September, 1973.
- Weisbrod, A. R. In press. Varied Thrushes Feeding in the Intertidal Zone. *The Murrelet*. Accepted September, 1973.
- Field, D. R., and M. H. Cheek, Jr. 1973. A Basis for Assessing Differential Participation in Water-Based Recreation. Paper prepared for the Ninth American Water Resources Conference, Seattle, Washington, October 1973.
- Field, D. R. July 1973. Sociological Dimensions of Leisure Involvement in Water-Based Recreation. Report to the State of Washington Water Research Center, University of Washington. 43 p.
- Field, D. R., and J. A. Wagar. 1973. Visitor Groups and Interpretation in Parks and Other Outdoor Leisure Settings. *The Journal of Environmental Education*. Vol. 5, No. 1, Fall 1973.
- Field, D. R. 1973. The Telephone Interview in Leisure Research. *Journal of Leisure Research*. Vol. 5 (Winter):51-60.
- Field, D. R., and J. T. O'Leary. 1973. Social Groups as a Basis for Assessing Participation in Selected Water Activities. *The Journal of Leisure Research*. Vol. 5 (Spring): 16-25.

### 4. Invited Presentations:

- Dr. A. R. Weisbrod: "Animal Components of the Northwest's Ecosystems", College of Forest Resources Honors Seminar Program.  
"Impact of the Alaska Pipeline on Local Fauna", Institute of Environmental Studies, University of Washington.  
"Effects of Pesticides on Birds", College of Forest Resources, University of Washington.  
"The 1972 Noatak Expedition", Department of Zoology and College of Forest Resources, University of Washington and Cornell University.
- Dr. D. R. Field: Speaker on Social Science Research, National Park Service, at National Parks and Recreation Conference, November 1973.  
"Profiles of Visitor Groups", Concessions Management Conference, Grand Canyon National Park, February 1973.  
Speaker, Interpretive Training Course, Harpers Ferry, West Virginia, April 1973.  
Speaker, Interpretation Conference, Olympic National Park, April 1973.  
Speaker and participant in Interpretive Training Course, Pacific Northwest Region, May and October 1973.

### 5. Teaching and Other Activities:

- Dr. Weisbrod teaches the following:  
"Zoological Field and Laboratory Techniques" (Winter & Spring Quarters) Forest Resources 556, University of Washington.  
"Ecological Adaptations of Animal Behavior" (Fall Quarter) Forest Resources 556, University of Washington.  
"On the Kingdoms of Organisms" (Winter Quarter) Forest Resources 557, University of Washington.
- Dr. Field teaches the following courses:  
"Sociology of Leisure and Outdoor Recreation", Forest Resources 452, University of Washington.  
"Sociology of Natural Resources," Forest Resources 467, University of Washington.

Dr. Weisbrod's consulting activities include work for the Alaska Task Force, USNPS, Anchorage, Alaska, and the Division of Zoology, Washington State Museum, Seattle, Washington.

Dr. Field has been appointed Adjunct Associate Professor of the Institute for Environmental Studies, University of Washington.

## WIND CAVE NATIONAL PARK

### ENERGETIC COSTS OF BEHAVIORS OF FREE RANGING PRAIRIE DOGS WICA-N-3

INVESTIGATOR: Gordon F. Lund  
University of Iowa

SUMMARY OF  
PROGRESS: All experiments have been completed along with the scoring and analyses of data. Completion of reports should be accomplished in the near future at which time copies will be submitted to the park service.

# # #

### BEHAVIOR AND ECOLOGY OF THE PRONGHORN (*ANTILOCAPRA AMERICANA*) WICA-N-11

INVESTIGATOR: Peter T. Bromley  
University of Calgary

SUMMARY OF  
PROGRESS: Field work was completed in November 1972. Significant findings were reported in previous Investigator's Annual Reports. Analysis of data and preparation of the manuscript have not been completed. The investigator intends to complete the project; however current demands on his time from his job and family will restrict intense work on the project.

## YELLOWSTONE NATIONAL PARK

### BIOTIC SUCCESSION OF LODGEPOLE PINE FOREST OF FIRE ORIGIN IN YELLOWSTONE AND STUDY OF PLANT SUCCESSION IN LODGEPOLE PINE YELL-N-16b

INVESTIGATOR: Dale T. Taylor  
Sterling College

SUMMARY OF  
PROGRESS: Avifauna on the 281 A. 1966 Central Plateau, 46 A. 1954 Kiewit, and 117 A. 1966 Otter Creek burns were censused for comparison with the 1967 and 1971 data to further establish successional trends.

Thirty-eight Tree Swallow nests and 11 Mountain Bluebird nests and nests of 10 other species were followed from time of establishment until 1 August when most had fledged. Parameters such as tree species used for nesting, tree size, hole height, direction hole faced, sill size, cavity, and depth to the nest were measured for each nest hole. Preliminary evidence shows extreme competition for nesting sites occurs between Tree Swallows and Mountain Bluebirds. In addition, lack of nest sites due to fire control may be detrimental to Mountain Bluebird populations.

# # #

### ELK ECOLOGY STUDIES, YELLOWSTONE NATIONAL PARK YELL-N-29b

INVESTIGATOR: Douglas B. Houston

OBJECTIVE: To test research hypotheses relating to elk habitat relations, biotic succession, interspecies relations, and ecological homeostasis to determine if or to what extent different portions of the northern Yellowstone elk require management.

METHODS: The hypotheses under investigation, methods of evaluation, criteria for rejection, and some preliminary interpretations have been presented elsewhere (Houston 1971).

RESULTS AND  
DISCUSSION: Evaluations of these hypotheses have continued (Houston 1973a, b). The history and population dynamics of the northern Yellowstone elk have been reviewed (Houston 1973b). A number of premises used in support of past herd reductions (the park was not historical elk winter range, the elk herd erupted to 35,000 following establishment of the park, the herd crashed to 11,000 in the winter of 1919-20 with concurrent range destruction) have not been supported by the reviews of historical information. The demographic characteristics of the population (numbers, natality, composition, age structure, dispersal, etc.) have been described for the different herd sizes which resulted from human predation (i.e., hunting removals outside the park; herd reductions inside the park). The hypothesis to allow segments of the northern herd wintering in the park to be "naturally regulated" has not been rejected--and artificial regulation of those segments has not been recommended. Management recommendations have been submitted annually for consideration by the Montana Fish and Game Commission for herd segments wintering outside the park. To date these have not been implemented because of low numbers of elk wintering outside park boundaries.

PLANS FOR 1974: Continue studies of ungulate habitat relations, social organization of elk, winter distribution of ungulates, forage utilization, and range trends. Begin analysis of plant succession and range trend as documented by historical photos and early range measurements.

Publications:

- Houston, D. B. 1971. Status of research on ungulates in northern Yellowstone Park. Unpubl. ms., Yellowstone National Park.  
\_\_\_\_\_. 1973a. Wildfires in northern Yellowstone Park. *Ecology* 54:1111-1117.  
\_\_\_\_\_. 1973b. History and demography of the northern Yellowstone elk: a re-evaluation. (in preparation)

# # #

MICROBIAL ECOLOGY OF YELLOWSTONE GEOTHERMAL AREAS  
YELL-N-34,49

INVESTIGATOR: Thomas D. Brock  
University of Wisconsin, Madison

SUMMARY OF My laboratory group has been studying the ecology of thermophilic micro-organisms in Yellowstone geothermal areas for 8 years, and our 1973 studies were part of that continuing research program. During the past year, our attention has been focused on three general areas: (1) *Algal stromatolite structures*. Stromatolitic structures are forming in a number of Yellowstone hot springs. Knowledge of the processes involved in their formation should provide insight into the formation of similar structures formed during the Precambrian period. The primary organism forming these structures is the blue-green alga (*Phormidium tenue* var. *granuliferum* Copeland) but the gliding photosynthetic bacterium (*Chloroflexis*) is associated with it. (2) *Algal-bacterial mats*. Under different conditions and in association with the blue-green alga (*Synechococcus lividus*), *Chloroflexis* also occurs in the algal-bacterial mats that are prevalent in alkaline hot springs. These mats are ideal ecosystems for studying algal-bacterial interactions, specifically the transfer of nutrients from the alga to the bacterium. Our recent studies show that *Chloroflexis* is capable of assimilating organic compounds produced and excreted by the *Synechococcus*. (3) *High-temperature sulfur-oxidizing bacteria*. We have found that the recently discovered bacterium (*Sulfolobus acidocaldarius*) is a major producer of sulfuric acid in acid geothermal areas, especially at higher temperatures. We have obtained estimates of sulfuric acid production in several acid hot springs and using a new method, we were able to determine the growth rates of these bacteria in their natural habitat.

Many aspects of the ecology of these unusual thermophilic microorganisms remain to be investigated, and we hope to continue our studies in future years.

# # #

ANIMAL ECOLOGY STUDIES IN YELLOWSTONE NATIONAL PARK  
YELL-N-38

INVESTIGATOR: Glen F. Cole

OBJECTIVES: *Project IA.* To obtain basic reference information on the habits, population dynamics, and ecological relationships of managed and naturally regulated elk populations.

*Project IIB.* Establish systems for routinely measuring the population status and trends of representative faunal species.

METHODS: *Project IA.* Field observations and measurements of vegetation are made in the Gibbon, Madison, and Firehole rivers study area to document the habits, population dynamics, and ecology of a naturally regulated elk (*Cervus canadensis*) population.

*Project IIB.* Field observations of rare or endangered species are compiled and analyzed to determine if their population status and trends can be routinely monitored.

RESULTS AND DISCUSSION: *Project IA.* The study has continued since June of 1967. The elk population was on a year-to-year basis mainly self-regulated by density-influenced intraspecific competition for space, nutrients, or mates (adult males only). These can be considered limiting factors, or K. The resulting highly age-specific mortality was compensated for (with lags) by density-influenced natality. Extrinsic influences from periodic harsh weather intensified intraspecific competition for space or nutrients, contributed to lags in compensating natality, and increased the efficiency of grizzly bears (*Ursus arctos*) as predators (Cole 1972).

Over ecological time, plant succession has and will continue to influence K, as available space or nutrients, and therefore elk population size (Cole 1971). Except for small areas that remained free of snow or meadow-forest ecotones which elk and an associated bison (*Bison bison*) population maintained in a disclimax (also called zootic climax stage), the biotic effects of these and other native herbivores did not prevent plant succession toward climax. The effects of natural fires needs further study.

The studied elk population served as food for native predators and scavengers. These included grizzly bears, black bears (*Ursus americanus*), coyotes (*Gulo luscus*), Bald Eagles (*Haliaeetus leucocephalus*), and a remnant group of gray wolves (*Canis lupus*). Predation did not prevent the elk population from being regulated by intraspecific competition and from ultimately compensating for all natural mortality. The principal effects of predators and scavengers as an interacting unit (Cole 1972) appeared to be to hasten the deaths of elk that had the lowest nutrient or energy reserves and thereby dampen elk population fluctuations. Such culling also contributed to maintaining most adult female elk at prime breeding ages (probably 10 years or less) and a relatively high yearly production of young (usually about 50 calves/100 females going into winter).

*Project IIB.* Data from field observations of grizzly bears, gray wolves, bald eagles, mountain lions, and wolverine have been compiled for reference use. The accumulated data on gray wolves, mountain lions, and wolverine are in research notes by Cole (1971) and Houston (1972). Preliminary information from research to establish methods to monitor the population status and trends of Bald Eagles and Ospreys (*Pandion haliaetus*) is reported by Swenson (1973). Data on grizzly bears are used in a series of research notes, conference papers, and publications since 1968. See Cole (1973a) for the information through 1972.

An Interim Report (Cole 1973b) that has been submitted for publication uses observation and life history data to calculate the size and trends of the park's grizzly bear population. Observations over an additional number of years are needed to determine if this method can be routinely used.

PLANS FOR 1974: Continue research on the Gibbon, Madison, and Firehole rivers study area and the development of routine systems to reflect the population status and trends of rare or endangered species.

References:

Cole, G. F. 1971. An ecological rationale for the natural or artificial regulation of native ungulates in parks. *Trans. 36th N. Am. Wildl. Natur. Res. p.* 417-425.

- \_\_\_\_\_. 1971. Yellowstone wolves (*Canis lupus irremotus*). Res. Note No. 4, Yellowstone Nat. Park. 6 p. (mimeo.)
- \_\_\_\_\_. 1972. Grizzly bear-elk relationships in Yellowstone National Park. *J. Wildl. Mgmt.* 36(2):557-561.
- \_\_\_\_\_. 1973a. Management involving grizzly bears in Yellowstone National Park, 1970-72. Res. Rpt. No. 7, National Park Service, Govt. Printing Office. 10 p.
- \_\_\_\_\_. 1973b. Management involving grizzly bears and humans in Yellowstone National Park, 1970-73--an interim report. (ms. for publ.)
- Houston, D. B. 1972. Cougar and wolverine in Yellowstone National Park. Res. Note, Yellowstone Nat. Park. 2 p. (mimeo.)
- Swenson, J. and R. L. Eng. 1973. Yellowstone National Park Bald Eagle-Osprey study. 1973 progress report. 4 p.

Other papers:

- Cole, G. F. 1971. Some considerations in the use of exclosures to assess the biotic effects of herbivores and departures from natural conditions in Yellowstone National Park. Information Paper, Yellowstone Nat. Park. 2 p. (mimeo.)
- \_\_\_\_\_. 1971. Animal ecology studies in Yellowstone National Park. Annual Report, YELL-N-38, Yellowstone Nat. Park. 5 p. (mimeo.)
- \_\_\_\_\_. 1971. Progress in restoring a natural grizzly bear population in Yellowstone National Park. AAAS, Research in National Parks Symposium. 21 p. (mimeo.)
- \_\_\_\_\_. 1971. Preservation and management of grizzly bears in Yellowstone National Park. *Bioscience* 21(16):858-865.
- \_\_\_\_\_. 1972. Restoration of a natural grizzly bear population in Yellowstone National Park. Information Paper, Yellowstone Nat. Park. 1 p. (mimeo.)
- \_\_\_\_\_. 1973. Management involving grizzly bears in Yellowstone National Park, 1970-72. Information Paper, Yellowstone Nat. Park. 2 p. (mimeo.)

# # #

PLANT ECOLOGY STUDIES  
YELL-N-39

INVESTIGATOR: Don G. Despain

OBJECTIVES: I. Research leading to publication which classifies and describes natural units of park vegetation and documents successional processes for major plant species and entire vegetational units. II. Research leading to publications of the ecology and trophic roles of major plant species and vegetational units.

SUMMARY OF PROGRESS: Due to the favorable research climate in Yellowstone, I was able to get both my master's and doctor's theses into publication. "Vegetation of the Bighorn Mountains of Wyoming" appeared in *Ecological Monographs*, and "The Survival of Saguaro Seedlings" will appear in the *Arizona Academy of Science Journal*. I also aided in a synthesis of tree ring data taken from Yellowstone the previous summer, which may in the end result in a publication on Yellowstone's past climate.

A paper on the recreational productivity of lodgepole pine was prepared and presented at a lodgepole pine symposium at Washington State University in Pullman, Washington, this fall. The paper will appear in the proceedings of that symposium, hopefully within the next 3-4 months.

I have also cooperated in testing the ability of ERTS A to map the vegetation of Yellowstone and am finding a little frustration in working with geologists and mathematicians. However, there is some room for further investigation in this area and I will continue to cooperate.

We have embarked on a natural fire program in Yellowstone. In our second year we monitored one fire that exceeded our previous year's fire by 80 ft. We are still waiting for our big fire. In the meantime, I continue to improve research methods and procedures, and broaden and strengthen our background knowledge of past fire history.

Additionally, data has been gathered that is being worked into a paper on lodgepole pine as a nonpyrogenic climax community. Hopefully, this can be submitted to an ecological journal before long.

Specimens in the Yellowstone Herbarium were boxed and sent to the Rocky Mountain Herbarium where I was able to update and improve the determinations of the approximately 3000 sheets. Several species new to Yellowstone have been added to the Herbarium through my own collecting efforts and those of some naturalists with whom I am cooperating. Before spring a reliable checklist of Yellowstone flora will appear with possibly an accompanying key.

# # #

### TROPHICDYNAMICS OF THERMAL SPRING ECOSYSTEMS YE11-N-53

INVESTIGATOR: Richard G. Wiegert  
University of Georgia

SUMMARY OF PROGRESS: During 1973, work under this grant from NSF was concentrated on: (1) ecology of the algae-midge-mite communities characteristic of some intermittent and thermal outflows; (2) comparative studies of algal productivity in 17 different springs located in an arc from West Thumb to beyond Twin Lakes on the Norris-Mammoth Road; (3) ecology of spiders in Serendipity Meadow (off Firehole Lake Drive); (4) ecology of parasitic wasps in the Serendipity and Terrace Springs areas; (5) preliminary attempts to adapt a hand-held radiometer for measurement of algal biomass; and (6) continued development of an ecosystem model that will predict the response of thermal ecosystems to perturbations.

The field work for project (1) has been completed. These simple predator prey systems are useful natural models of comparable laboratory systems. The stability of the community is due to the toleration by midges and mites alike of prolonged food scarcity and the provision, by differential adaptation, of a higher temperature refuge for the midge prey.

Project 2 was begun in the summer of 1973 and will be continued. The various outflows studied show wide differences in productivity, water chemistry, and temperature. Analysis of the data should provide some valuable information on both the factors controlling thermal algal productivity as well as permitting the delineation of similar "functional" species groups of blue-green algae. The latter information is vital for the modelling phase of the research.

Projects 3 and 4 are just beginning. Their objectives are to learn enough about the ecological interactions of each group (spiders and wasps) to be able to predict their role in and effect on the alkaline thermal effluent systems. To date we have found that the wasps could potentially decimate the normal grazing fly populations of certain algal mats (but seldom do so) whereas the spiders may not control, but rather be dependent upon, the prey populations.

Project 5, the attempt to adapt a method of infrared sensing to the sampling of algal biomass was only partially successful. However, the results obtained by trials in 1973 suggest that further effort will be worthwhile in 1974. The potential benefits are great, since the method could reduce the sampling time necessary for algal biomass studies by 95%.

Project 6 is the continuing development of a predictive, validated ecosystem model. The most important finding in 1973 was that condensation of model components in a greatly simplified form could yield good predictions provided (a) that the components all utilize the same resource; (b) that the combined or multi-species component reacts to the controlling variables in the same manner as do its constituent species; and (c) that all constituent species have roughly similar maximum rates of growth.

A detailed report of the research conducted during the past 2 years and proposed work for the years 1974-75 is given in the renewal proposal sent to NSF in December 1973. Copies are on file in the Office of the Supervisory Biologist and Chief Park Naturalist.

# # #

THE ROLE OF SOIL TEMPERATURE IN TIMBERLINE FORMATION  
YELL-N-57

INVESTIGATOR: George G. Spomer  
University of Idaho

SUMMARY OF PROGRESS: Research activities this past season were centered on the Beartooth and Hellsroaring plateaus adjacent to Yellowstone. Tree seedlings were collected for use in controlled environment studies (currently in progress) of the effects of shoot and root temperatures on growth and development of timberline species. Also a survey was made of the soil fungi and mycorrhizal activity associated with timberline trees. These observations indicated considerable activity which may contribute significantly to the survival of trees at the higher elevations, but much more work is necessary to confirm this. Mr. Higgins, a Ph.D. student, collected herbaceous plants above and below timberline for controlled environment studies of root respiration in relation to soil temperatures. (Some studies were also conducted in the field.) Preliminary results from these studies indicate that alpine endemics (*Geum rossii*) may have significantly higher respiration rates at lower temperatures than species excluded from the alpine (*G. triflorum*). He is looking for confirmation of these results in comparisons of alpine and subalpine populations of *Achilleum millefolium*. His results to date tend to further support the hypothesis that soil temperature is an important factor in the establishment and distribution pattern of vegetation at higher elevations.

Hopefully, the information derived from these studies will be useful in the management of high elevation vegetation and reestablishment of timberline forests as well as repair of grazing damage in alpine meadows.

# # #

POPULATION STRUCTURE AND GROWTH RATE OF *SCELOPORUS GRACIOSUS*  
*GRACIOSUS* (SAGEBRUSH LIZARD) NEAR NORRIS GEYSER BASIN  
YELL-N-65

INVESTIGATOR: Robert E. Moore  
Montana State University

SUMMARY OF PROGRESS: Several trips were made during summer of 1973 to gather data on growth rates of various age classes. The findings to date are the same as reported in the annual report for 1972.

Field work in 1974 will concentrate upon estimations of numbers of lizards in the various age classes at the end of hibernation, mid-summer, and autumn after hatching of young-of-the-year.

# # #

SYSTEMATIC INVESTIGATIONS OF INDIGENOUS TROUTS OF  
NATIONAL PARKS AND CONTIGUOUS WATERS  
YELL-N-70

INVESTIGATOR: Robert Behnke  
Colorado State University

SUMMARY OF PROGRESS: There are several subspecies (some undescribed) involved within the framework of the project title. In 1972 and 1973 the most apparent and readily defined problems have been handled, with emphasis on developing information leading to restoration of the native trout to National Park waters or for a fisheries management program.

With supplementary funds in 1973, one M.S. thesis was completed on four subspecies of cutthroat trout and two theses are scheduled for completion in June 1974 on the native cutthroat trouts of the Columbia and Missouri river basins.

The graduate student thesis: Native cutthroat trout of Colorado, provided the information necessary to proceed with an attempt to restore the native greenback cutthroat trout (*Salmo clarki stomias*) to Rocky Mountain Park. Brook trout were eradicated from Hidden Valley Creek in the park in September and 80 greenback trout were introduced on 16 October 1973. A small population of Colorado River cutthroat trout (*S.c. sleuriticus*) was found in the very headwaters of the Colorado River in Rocky Mountain Park, providing a potential source for the reestablishment of this subspecies into tributaries of the Colorado River in the park.

The two theses in progress concern the native cutthroat trout of the Columbia and Missouri river basins which include the westslope, eastslope, and South Saskatchewan cutthroat trout of Glacier National Park and the cutthroat trout native to the upper Snake River of Teton and Yellowstone Park and the Yellowstone and upper Missouri rivers of Yellowstone Park.

Collections and examination of specimens, including ancient museum material, revealed at least two basic types of cutthroat trout are native to the middle and upper Columbia River drainage. A large-spotted cutthroat trout appears to be virtually extinct in its former range at present, but it is apparently the ancestral form of the two distinct types of cutthroat trout in the upper Snake River and also of the Yellowstone cutthroat trout.

The cutthroat trout of the upper Missouri drainage is derived from "westslope" cutthroat trout typical of the Clark Fork drainage of the Columbia basin and both the westslope cutthroat and upper Missouri cutthroat should be classified as *S. C. lewisi*. Collections in Utah in the summer of 1973 verified that trout are native to headwater tributaries of the Virgin River (Zion National Park). The Virgin River trout appear to be identical to the Bonneville basin cutthroat trout (*S. c. utah*). Supplementary data were also gathered and reports written on some endemic Virgin River fishes which are rapidly declining (spinedace, *Lepidomeda mollispinis*; woundfin, *Plagiopterus argentissimus*; and chub, *Gila robusta seminuda*).

With the information and reports now available on the native trout of North America and on rare and endangered fishes of the Southwest, I would suggest that a list of lands administered by the National Park Service be sent to me so information on regional fishes

can be made available to each office, alerting them to species which are rare and in need of protection and to species now extirpated from park waters which might be reestablished, such as the greenback cutthroat trout in Rocky Mountain Park.

# # #

HUMAN-WILDLIFE INTERACTIONS IN YELLOWSTONE NATIONAL PARK  
YELL-N-72

INVESTIGATOR: H. D. Picton  
Montana State University

SUMMARY OF PROGRESS: The research in progress is an attempt to determine (1) if significant interactions occur between backcountry users and wildlife, particularly the grizzly bear (*Ursus arctos*); (2) the type and magnitude of such interactions; and (3) measures to be taken to minimize the impact of any human disturbances on the above wildlife.

The study area consists of the northern two-thirds of the Gallatin Range in northwestern Yellowstone National Park. Specifically, the area lies between Sportsman Lake, Bighorn Pass, U.S. Highway 191, and the Grand Loop Road YNP. The entire area is essentially wilderness.

Data on the kinds and intensity of human use are being compiled from written records of backcountry use, including trail registers, backcountry use permits, communication center records, and mail questionnaires. This information has been and will be supplemented by field observations of party behavior. The questionnaire was mailed to each party that visited the study area during the summer of 1973, and are still being received. In addition to providing data on parties and human-wildlife interactions, the questionnaire may be used to formulate an index of interaction. This index could be a useful management tool in predicting the probability of interactions occurring between parties of certain types and specific wildlife species.

In order to study wildlife behavior as it relates to backcountry use, 64 days were spent in the field during the period 30 June to 19 September 1973. The study area was traversed six times in trips ranging from 7 to 12 days in duration. Observations of animal species, distribution in the study area, and animal behavior including flight, aggressive behavior, and daily activity behavior were made. These observations were made while traversing the area and while on fixed observation sites. Distribution trends were determined on 23 transects located near trails, campsites, and in areas seldom visited by backcountry visitors. The correlation between changes in animal behavior and distribution in the study area and the various kinds and intensities of human use will be determined.

The study will proceed much as originally planned. Data on early season human-wildlife interactions will be secured in order to supplement the mid and late season data already collected. Some time will be spent observing human-wildlife interactions along the heavily traveled roads of Yellowstone National Park. This data will serve as useful reference data in the observation of wildlife that is not as habituated to the human presence. The questionnaire will be modified and distributed to backcountry users as they sign out for a trip. It is anticipated that intensive field observations will again begin in early June 1974 and terminate in mid-September. The data will be analyzed and the final report will be written during fall and winter quarters, 1974-75.

FOOD HABITS OF GRIZZLY BEAR IN YELLOWSTONE NATIONAL PARK AND VICINITY  
YELL-N-74

INVESTIGATORS: Harold Picton & Associates  
Montana State University

SUMMARY OF PROGRESS: Two months and 10 days (1 July - 10 Sept.) were spent in Yellowstone National Park in field investigation and 4 months were spent at Montana State University in graduate course work in the Fish and Wildlife Management curriculum. During the period of field investigations, approximately 175 grizzly bear scats were collected. These scats were transported to the Wildlife Research Laboratory on the Montana State University campus for analysis. A preliminary report of this analysis will be prepared in June 1974. Future field investigation will continue to concentrate on scat collection activities. Such effort will serve to broaden the present sample. This material will provide data concerning frequency of occurrence of animal and vegetative matter in the grizzly bear diet. Plant and animal collections will be made to provide information about grizzly bear digestive efficiency through analysis of food values present before and after digestion. Such information will contribute to a definition of the trophic niche of the grizzly bear.

# # #

CLIMATOLOGY, GRAND TETON AND YELLOWSTONE NATIONAL PARKS  
YELL-N-75

INVESTIGATOR: Richard A. Dirks  
University of Wyoming

SUMMARY OF PROGRESS: Data collection, error correction, and smoothing for missing data have been completed for the 30-year period, 1941-70, for the 16 stations in the park area. Climatological normals have been obtained for several of these stations.

Collection of historical records of published data has been largely completed. Historical records of site descriptions for climatological stations have also been assembled and are near completion. A considerable effort has been expended in seeking out data collected in special studies in the parks and their vicinity. To date, only a small amount of data has been derived from such studies. Preliminary examination has also been made of short-term and intermittent data, e.g. fire weather observations, snow surveys.

It is evident that several major gaps exist in climatic data for the parks: (a) complete records exist only for stations located at low elevations in the parks. Observations are very sparse for the vast higher elevation, exposed regions of the parks; (b) detailed wind data is limited to several stations outside the park boundaries. Within the parks, data is scarce and existing data are quite seasonal.

COMPUTER GENERATED LAND COVER TYPE MAP OF YELLOWSTONE PARK  
PRODUCED FROM ERTS MULTISPECTRAL SCANNER DATA

INVESTIGATORS: Ralph R. Root) Denver Service Center  
Harry Smedes ) U.S. Geological Survey  
Don Despain ) Yellowstone National Park  
Norm Rollor ) Environmental Research Institute of Michigan

SUMMARY OF PROGRESS: The purpose of the study was to test the feasibility and accuracy of mapping ground cover types via computerized interpretation of Earth Resources Technology Satellite multispectral imagery. Eleven mapping categories were selected based on their ecological significance and spectral character. Computer mapping was done for the entire park by supervised computer recognition routines using a maximum likelihood decision rule. The recognition map was displayed as an 11 color 12 x 18 inch photo produced by a digital ink-squitter device. Accuracy of the map was checked in 10 test areas of 15 square miles each, where point and area comparisons were made between the recognition map and control data obtained from analysis of NASA high altitude photography. Results indicate the feasibility of automatically producing plant community type maps in wildland areas. There is a potential application of this technique in producing certain types of Resources Basic Inventory (RBI) data in national park areas.

The study will be published in the Proceedings of the 9th International Symposium on Remote Sensing of Environment, and will be further documented in a Ph.D. dissertation entitled "Computer Terrain Mapping of Yellowstone Park", Department of Earth Resources, Colorado State University, Fort Collins, Colorado. Expected completion date: September 1974.

# # #

ECOLOGY OF BISON  
YELL-N-8b

INVESTIGATOR: Mary Meagher

OBJECTIVES: *Project 1.* (a) To provide more information on bison population dynamics and environmental relationships; (b) to determine the extent to which natural means will regulate population numbers. *Project 2.* To provide a comprehensive "ecological history" of Yellowstone's early years for: (a) additional historical data on bison populations; (b) for other research problems, as needed.

METHODS: *Project 1.* Continued extensive field observations will be made by all possible means. Aerial observations are essential for census, classification, and distribution information. Ground observation work will provide more detail on population and environmental factors. Work on vegetation trends continues with use of historical data and photographs.

*Project 2.* A punch card system of tabulating historical information is in use. Published accounts and a great volume of unpublished material (primarily Yellowstone archive and research library sources) are being systematically searched. Historical photos have been located, retaken, and filed by geographical location.

RESULTS AND DISCUSSION: *Project 1.* The Mary Mountain population unit is still in a marked increase phase after termination of reductions in 1966. However, reestablishment of a significant west side summering population has not yet occurred. By comparison, the Lamar population (reductions terminated in 1965) continues to increase very

slowly. Winters continue to be mild, especially on the northern range a severe winter park-wide is needed to answer some questions. Total population estimate for early winter is 850.

Although only indirectly related to the research work, the bison-brucellosis controversy should be mentioned. Perhaps 10% of my time this year (25% in 1972) has been spent on gathering information, preparing statements, and handling correspondence related to the pressure by livestock interests-USDA brucellosis eradication program personnel to "sanitize" the Yellowstone bison.

*Project 2.* Tabulation of ecological information from Army scout diaries and reports which span 1897-1916 has been completed. Approximately four volumes (of 20) of the Army station record books and some miscellaneous accounts are done. Use of Aubrey Haine's files for location of sources is complete. A better assessment of the size of the job leaves me with a 10% estimate for material worked to date.

Several things are emerging from the tabulation to date. Moose were not wintering on the northern range in early park history--they arrived approximately about 1915. There was a beaver "high" about the turn of the century, and a wolf "high" perhaps 1915-20. Cougars were common; they preyed predominantly on elk. There was an impressive grizzly bear population in the upper Lamar country. No attempts at interpretation of these occurrences will be made until the tabulation is finished. The collective efforts of all of us will be necessary for this.

One hundred fifty historical photos (exclusive of the Northern third of the park) have been located, retaken, and mounted. Captions are not yet complete, and there are perhaps half a dozen photos still to retake. The increase in forest cover, parkwide, is one of the most obvious changes shown by the photos. Lack of change in vegetative cover on some sites is equally striking.

PLANS FOR 1974: *Project 1.* Plans are similar to those of last year. Work will continue on population dynamics, habits, and distribution as the population continues to increase toward K (particularly the Mary Mountain segment), and natural regulatory factors.

I anticipate that the brucellosis controversy will continue to absorb time and energy.

*Project 2.* A few historic photos remain to be retaken--these will be completed. The search of presently available photo collections is done; the Haynes collection remains an untouched mine.

Effort will continue to be concentrated on tabulation of historical information from unpublished sources--these are generally least available to other persons. I anticipate finishing the remaining 16 Army station records (some have very little information).

Field work necessary to "make sense" of the early information will continue.

Publications:

Meagher, M. 1973. The bison of Yellowstone National Park: past and present. Scientific Monographs. No. 1. Nat. Park Serv. Govt. Printing Office, Washington, D.C.

Two Yellowstone National Park Information Papers were revised:

"Brucellosis in Yellowstone bison--the controversy" No. 14 (rev.)  
"A boundary control program for Yellowstone bison."

## YELLOWSTONE NATIONAL PARK BALD EAGLE-OSPREY STUDY

INVESTIGATORS: Jon Swenson )  
Robert L. Eng) Montana State University

SUMMARY OF PROGRESS: Full time field work in 1973 was begun on 11 June, a continuation of last summer's work on the Bald Eagles (*Haliaeetus leucocephalus*) and Ospreys (*Pandion haliaetus*) in Yellowstone National Park.

Three aerial surveys have been made to date, one each on 12 and 29 May and 20 June. The first flight was primarily to check for early Bald Eagle nesting activity, and thereby detect any early abandonment of nesting effort. Only five Ospreys were seen on nests in incubation posture on 12 May, indicating that the egg-laying period had just begun.

Systematic censusing of the Yellowstone River for Osprey foraging activity was initiated this year. Although too few data have been collected for any valid interpretations this far, the indications are that the Ospreys prefer the portions of the Yellowstone River which are open and closed to fishing. The censusing will continue throughout the summer. It is also planned to census foraging Ospreys, and Bald Eagles incidentally, on Yellowstone Lake to determine favored fishing areas, prey size and, hopefully, human-prey fishing interactions.

All available prey data will be gathered. Preliminary data from last year suggest that waterfowl and fish were the primary food items for Bald Eagles, although a few mammals were also taken. Little data are available on the species composition of Osprey prey.

Twice in 1972, on 17 and 28 June, I observed Ospreys exchanging incubation duties, with both sexes observed incubating. Apparently, there has been only one published record of male American Ospreys incubating (Garber and Koplín 1972).

Murphy (1961) estimated a winter population of about 12 Bald Eagles in the park, but speculated that the numbers would vary according to environmental conditions. I received 48 reports of Bald Eagles in the park, mostly from park personnel, from October 1972 to March 1973 which tend to confirm this hypothesis. At least 14 Bald Eagles were present in October, they decreased in abundance during the harder winter months, and then increased in March (Fig 1). Bald Eagles were scattered throughout the park in October, but were concentrated along the lower Yellowstone River and Madison-Firehole-Gibbon area from December to February. Reports suggest that they begin moving to breeding territories in late March and early April.

Although late winter sightings may be lower because of inclement weather and more restricted human movements, it is quite probable that the eagles move out of the park during the hard winter months. This is supported by sightings of Bald Eagles outside the park in the winter and the fact that none was reported during the winter ungulate surveys on the northern range. No immature Bald Eagles were seen within the park from November to February. Between 2 and 13 Bald Eagles have been seen during the midwinter waterfowl and eagle surveys, suggesting a wide variation in the numbers of overwintering eagles from year to year.

To confirm to more standardized definitions, the status of two Osprey and one Bald Eagle nests from 1972 were changed from active to inactive. However, this does not significantly change the productivity data given in the 1972 progress report. I follow the terminology proposed by Henry and Van Velzen (1972) for Ospreys, i.e., an active nest is one containing eggs, and that proposed by Postupalsky (in press) for Bald Eagles, i.e., the presence of an adult pair associated with a nest early in the season constitutes an active nest.

Since it is early in the season, there is little 1973 productivity data to be compared with 1972. However, the reproductive efforts can be compared. In 1972, nine Bald Eagles nests were active. This year, there were 10 active nests, three of which contained a total of four young on 20 June.

There were 29 active Osprey nests last year. This year, 20 nests are active, two of which have already failed. Reports on the status of the two Bechler nests, which were active last year, have not yet been received. Of the nests for which 1973 data are available, there are three new nests (located first in 1973), six unsuccessful nests last year are inactive this year and one nest was blown down over the winter. All successful nests last year are active this year. Five active Osprey nests have been located in the Grand Canyon of the Yellowstone this year, as compared to two last year.

At this date, it can only be said that the Bald Eagle and Osprey reproductive efforts and breeding populations and the Bald Eagle hatching success seem to be essentially the same this year as in early 1972.

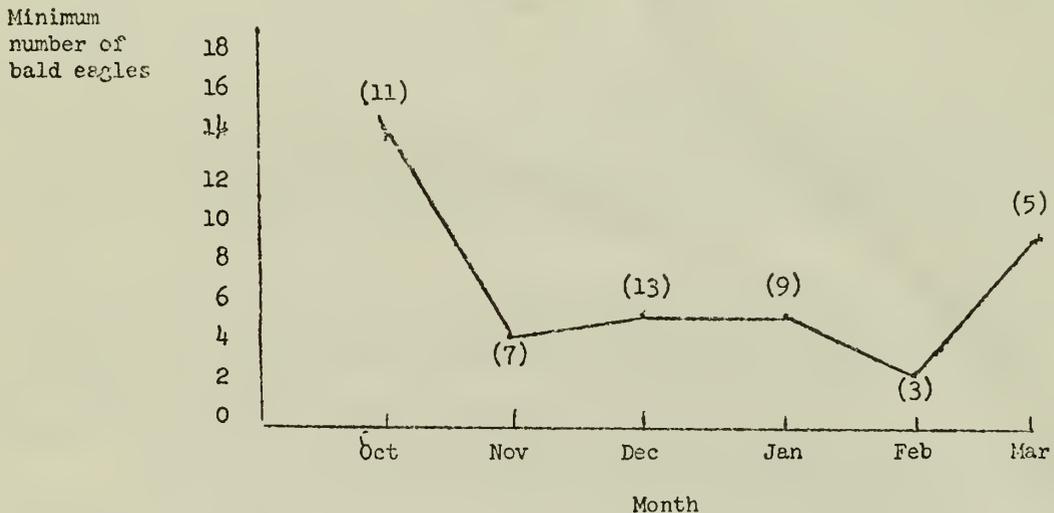


Fig. 1. Minimum Bald Eagle population sizes during the winter months of 1972-73 in Yellowstone National Park. Numbers of observations are in parentheses.

References:

Garber, D. P., and J. R. Koplín. 1972. Prolonged and bisexual incubation by California ospreys. *Condor* 74:201.

Henny, C. J., and W. T. Van Velzen. 1972. Migration patterns and wintering localities of American ospreys. *J. Wildl. Mgmt.* 36:1133-1141.

Murphy, J. R. 1961. Ecology of the bald eagle in Yellowstone National Park. Progress Report No. 2 - 1961. 12 p. Report to Nat'l. Park Serv.

Postupalsky, S. in press. Studies of reproductive success in raptors: Some problems with criteria and terminology. Conf. on Raptor Conserv. Techn., Fort Collins, Colo. March, 1973.

## STUDY OF BACTERIA IN HOT SPRINGS

INVESTIGATOR: John McGillis  
Salt Lake City

SUMMARY OF PROGRESS: From nine samples collected to date, six cultures of sulfolobus bacteria have been started. Once sufficient quantities of sulfolobus bacteria have been grown, (1975) tests of their ability to convert sulfur to sulfuric acid in acid mine dump environments will be initiated.

# # #

## A TAXONOMIC REVISION OF THE GENUS *PHILONOTIS* FOR NORTH AMERICA, NORTH OF MEXICO

INVESTIGATOR: William M. Zales  
Joliet Junior College

SUMMARY OF PROGRESS: The genus *Philonotis* (Musci) is revised for North America, north of Mexico, and exclusive of Greenland, following the last revision for this region by Seville Flowers in 1935. Collections and field observations of all but two of the recognized taxa were made from a wide diversity of habitats throughout most of their geographic range in North America. Numerous collections were cultured in a uniform environment to determine the stability of taxonomically diagnostic morphological characters. The position of papillae on the leaf cells, the structure of marginal cells, and to some degree the leaf shape and leaf cell shape are stable characters that are not modified by the environment. All other morphological characters examined are ecophenic and cannot be utilized to segregate taxa.

The present revision recognizes seven species and two varieties; *Philonotis glaucescens* (Hornsch.) Broth., *P. longiseta* (Rich. in Michx.) Britt., *P. sphaerocarpa* (Hedw.) Brid., *P. marchica* (Hedw.) Brid., *P. capillaris* Lindb. ex Hartm., *P. fontana* (Hedw.) Brid. var. *fontana*, *P. fontana* var. *americana* (Dism.) Flow. ex Crum, *P. fontana* var. *pumila* (Turn.) Brid., and *P. yezoana* Besch. et Card. (new to North America).

Chromosome counts of  $n = 6$  for *P. glaucescens* and  $n = 12$  for *P. longiseta* are new reports.

Keys, descriptions, illustrations, and distribution maps are provided for the identification of the species.

### Publications:

- Zales, W. M., and H. Crum. 1970. *Sphagnum* in Sherlevoix County, Michigan. *Mich. Bot.* 9(2):114-115.  
Zales, W. M. 1971. Bryophytes of Goose Lake Prairie, Illinois. *Trans. Ill. Acad. Sci.* 64(3):222-224.

- 1) ACOSTIC-MAGNETIC STUDIES; YELLOWSTONE LAKE
- 2) EARTHQUAKE MONITORING, YELLOWSTONE-HEBGEN LAKE REGION

INVESTIGATOR: Robert B. Smith  
University of Utah

SUMMARY OF To date the National Science Foundation-sponsored University of Utah/  
PROGRESS: University of Wisconsin, Milwaukee, Yellowstone Lake project has obtained  
the following; 300 miles of seismic profiles and 30 piston cores. Initial  
interpretation indicates that the subsurface geology of Yellowstone Lake is complex with  
evidence of deep sedimentary channels, buried volcanic domes, and complex glacial features.  
Preliminary core analysis shows the top 8 ft of sediments in the deep part of the lake to  
be amorphous silica (diatoms) and two cores taken in the north end of the lake were "hot"  
to the touch of the hand (probably greater than 130°F).

Earthquake monitoring showed shallow earthquake activity along the west side of the  
South Arm, west of Frank Island, and in a pronounced cluster about 2 miles south of Fishing  
Bridge.

Interpretation of aeromagnetic data shows the depth of the Curie isotherm (525°C) to  
about 17 km beneath the Yellowstone caldera. This depth is the shallowest documented.  
Together with the earthquake and seismic data, the Yellowstone caldera has been interpreted  
to represent the result of an upper-mantle plume and as such may provide the basic force  
for plate breakup and contemporary tectonics of the western United States.

We are currently preparing detailed subsurface and bathymetric maps of Yellowstone lake.  
Plan calls for additional seismic profiles, heat flow measurements, paleo-magnetic measure-  
ments, and earthquake monitoring during the summer of 1974.

# # #

#### PALEOMAGNETISM OF THE YELLOWSTONE WELDED TUFFS AND ASSOCIATED AIR-FALL ASHES

INVESTIGATOR: Richard L. Reynolds  
University of Colorado

SUMMARY OF Field work in the Yellowstone Park vicinity was completed in September  
PROGRESS: 1973. Measurements on magnetic remanence, magnetization as a function of  
temperature, and thermal treatments should be completed by summer 1974.  
Detailed mineralogical work will be initiated shortly. Paleomagnetic study of air-fall  
ashes in the midwestern and western states will continue as planned.

# # #

## RESEARCH ON ECOLOGY OF THERMAL BASINS

INVESTIGATOR: Richard P. Sheridan  
University of Montana

SUMMARY OF PROGRESS: *Cyanidium caldarium* was collected from Nymph Springs, Yellowstone National Park. Crude cultures cloned and presently being assayed for Ribulose-1,5-diphosphate carboxylase activity.

# # #

## NEUTRON ACTIVATION ANALYSIS OF OBSIDIAN

INVESTIGATOR: David Ives  
University of Missouri

SUMMARY OF PROGRESS: The project thus far has consisted of the determination of various analytical parameters such as sample morphology, irradiation, decay, and counting times, and isotope selection. Actual analysis of the Obsidian Cliff samples is expected to take place during the 1st or 2nd quarter of 1974. These materials are subsumed under the name Project Curmudgeon and will be reported on as such. Expected results include the correlation of the analysis techniques and equipment of the University of Missouri and the University of Michigan, an important factor in the application of neutron activation analysis to archaeological materials.

# # #

## PALYNOLOGY OF THE FOSSIL FOREST OF YELLOWSTONE NATIONAL PARK

INVESTIGATOR: Lanny H. Fisk  
Loma Linda University

SUMMARY OF PROGRESS: Samples of fossilized "soil" associated with petrified stumps have been collected from most of the classic "Fossil Forests." Except for a few samples to recheck results and the need for a suite of samples from the Gallatin region outlined below, this phase of the field work is nearing completion.

Of the rock samples thus far processed to extract the pollen and spores, about 80% have yielded workable concentrations of palynomorphs. Well preserved assemblages have come particularly from blue-gray indurated tuffs which also contain well-preserved leaves and needles.

Over 150 forms have been recognized with roughly two-thirds already identified to at least the generic level. More precise taxonomic determinations and attempts to recognize equivalents are continuing. Pteridophytes and bisaccate gymnosperms are particularly abundant as are the Taxodiaceae. Two angiospermous families are also well represented: Juglandaceae with *Juglans*, *Carya* (several species), *Pterocarya*, *Platycarya*, and *Momipites-Englehardtia*, and Betulaceae with *Betula*, *Alnus*, *Corylus*, *Carpinus*, and *Populus*. When the remainder of the assemblage is included, the flora illustrates the high taxonomic and ecologic diversity characteristic of several other Tertiary floras which have usually been

explained by mixing during transport. These initial results clearly indicate that our understanding of this flora is far from complete. Detailed analysis of the palynomorph data along with extraction of forms from other Yellowstone localities is continuing.

RECOMMENDATIONS: Investigation of the palynology of the Yellowstone fossil forests will continue as planned in the NE section of the park. Analysis of samples collected through a detailed stratigraphic section at the classic Mt. Amethyst locality should be completed by mid-year 1974 and will represent the major portion of a Ph.D. dissertation by Fisk. The remainder of the samples collected in the Lamar River valley will be processed at leisure. Future plans are to expand palynological studies to the Gallatin fossil forests with the addition of Mr. Phil DeBord as principal investigator in this phase of the project. As the work progresses, we are confident that a clearer understanding of the paleoecology, paleoclimatology, and depositional history of these unique and already famous forests will be the result.

# # #

### THE SEDIMENTARY STRUCTURES ASSOCIATED WITH THE PETRIFIED FORESTS OF YELLOWSTONE NATIONAL PARK

INVESTIGATORS: Harold G. Coffin) Andrews University  
Arthur Chadwick )  
Lanny H. Fisk ) Loma Linda University

SUMMARY OF PROGRESS: Due to circumstances beyond control, I was unable to get to the Yellowstone area at all in the summer of 1973. However, some of the rock samples collected the previous summer were processed. A paper is presently in preparation based in part on these processed samples. This will be sent you when published along with others that are expected to appear in 1974. I think this particular project can be completed during the summer of 1974.

# # #

### NESTING ACULEATE HYMENOPTERA IN WEST THUMB AREA

INVESTIGATOR: Stephen L. Clement  
University of California, Davis

SUMMARY OF PROGRESS: I have published two papers on the biology of nesting aculeate Hymenoptera from the West Thumb area of Yellowstone National Park. Each paper deals with a previously unstudied species. The papers are:  
Clement, S. L. 1972. Notes on the biology and larval morphology of *Stenodynerus canus canus* (Hymenoptera: Eumenidae). *Pan-Pac. Entomol.* 48:271-276.  
\_\_\_\_\_. 1973. The nesting biology of *Melissodes (Eumelissodes) rustica* (Say), with a description of the larva (Hymenoptera: Anthophoridae). *J. Kansas Entomol. Soc.* 46:516-525.

Reprints of these papers will be forwarded to the Biologist's and/or Naturalist's offices when they are available to the author.

I wish to thank Mr. John Douglas (now at Rocky Mt. National Park) and Mr. George Algard (seasonal subdistrict Naturalist-Norris) for their encouragement while I was undertaking these studies.

PARASITES OF UNGULATES  
TETON NATIONAL PARK AND ADJACENT AREAS  
JACKSON HOLE BIO. RES. STA. PROJ. NO. 156

INVESTIGATOR: Robert C. Bergstrom  
University of Wyoming

SUMMARY OF PROGRESS: Management changes on the National Elk Refuge, Jackson, have apparently influenced the incidence of *Dictyocaulus viviparus* (elk strain) in elk in the Teton Park-Southern Yellowstone Park areas. The refuge has been maintained free of elk in the summers of 1972 and 1973.

In the fall of 1968, 80% of the yearling elk on the refuge were positive for *Dictyocaulus viviparus*. Forty-five percent in Teton National Park were then positive also.

During 1973 incidence of *D. viviparus* was low (15% by fecal analyses) in early February, high (53% by fecal anal.) in early June, moderate (29% by fecal anal.) by late July, and relatively low (21% by lung dissection) by November. Roughly one-half as many elk are now positive as in 1968.

The writer is very encouraged by these data. Wyoming Game and Fish Commission, Forest Service, Teton National Park (especially Bob Wood), Yellowstone National Park, and National Elk Refuge (espec. Russell Robbins) personnel have all cooperated very well with the writer and the University of Wyoming.

RECOMMENDATIONS: Investigate further the possibilities of improving herd health in Yellowstone elk. The present study indicates only one possibility among many. Brucellosis, Sarcosporidiosis, Trypanosomiasis, and other diseases probably increase directly as the concentration of elk in a given area increases.

# # #

STUDIES OF THERMOPHILIC MICROORGANISMS

INVESTIGATOR: Richard W. Castenholz  
University of Oregon

SUMMARY OF PROGRESS: The continuing project in Yellowstone National Park has, in 1973, been concerned primarily with the distribution of photosynthetic algae and bacteria in hot springs of different chemical compositions. The influence of dissolved sulfide, pH and bicarbonate, and silicate on the presence and abundance of certain thermophilic species was examined through detailed field collections in 1973. The principal areas studied this year (1-15 July 1973) were the Mammoth, Norris, and Clearwater hot springs. I hope to be able to continue this work during the summer of 1974. A manuscript on the distribution of thermophilic microorganisms in the Mammoth area is now in preparation.

DEVELOPMENT OF A HABITAT-TYPE CLASSIFICATION FOR FORESTED REGIONS OF MONTANA

INVESTIGATORS: Stephan F. Arno )  
Bernard L. Kovalchik) U.S. Forest Service  
R. Presby )

SUMMARY OF We found that we did not have time to sample in Yellowstone this past  
PROGRESS: summer (1973). Samples taken in 1972 (approx. 20) are being incorporated  
into our manuscript on the habitat types of Montana, which will be out for  
review in June 1974.

YOSEMITE NATIONAL PARK

ECOLOGICAL REQUIREMENTS OF MULE DEER  
YOSE-N-1a

INVESTIGATORS: D. Harms )  
R. Riegelhuth) Yosemite National Park  
A. Sansum )

SUMMARY OF Yosemite 1973 deer range investigations conducted to acquire basic field  
PROGRESS: data for annual and long range deer management included:  
(1) Reconnaissance of high summer ranges to delineate key browse fields.  
(2) Range survey of key areas  
(a) 14 permanent and 5 random vegetative transects read to determine browse composition,  
condition, trend, and deer days use.  
(b) an additional 18 random pellet group transects were read.  
(3) Establishment of 9 additional permanent range transects.  
(4) Establishment of 4 deer exclosures (7' x 7').  
(5) Establishment of permanent photo reference points on 14 range transects.  
(6) Winter and spring deer herd composition counts.

SIGNIFICANT Analysis of the field data indicated:  
FINDINGS: (1) Of 9 inspection areas, browse condition in 5 areas was evaluated as  
unsatisfactory and 4 determined as satisfactory. Seven areas were clas-  
sified in an upward trend; 2 in a static trend; and 0 in a downward trend.  
(2) Comparative analysis of transect data read in 1964 and again in 1973 for two inspection  
areas indicated that:  
(a) Buck Camp continues to receive heavy use.  
1. heavily hedged plants increased from 63% to 74%.  
2. seedling and young plants increased from 16% to 18%.  
3. decadent plants decreased from 10% to 4%.  
4. deer days use per acre decreased from 163 to 126.  
(b) Horsethief Canyon has sustained decreased deer usage and improved range condition.  
1. heavily hedged plants decreased from 26% to 1%.  
2. seedling and young plants increased from 15% to 55%.  
3. decadent plants decreased from 20% to 0%.  
4. deer days use per acre decreased from 49 to 14.

(3) Deer use varied from 14 to 44 deer days use per acre on summer range and 69 to 95 days on intermediate ranges.

(4) Fawn production reaching the winter range increased from 39/100 does (1972) to 54/100 does.

- RECOMMENDATIONS: (1) No post-season or special hunts are recommended in light of:
- (a) a static deer population.
  - (b) a gradual shift from static range conditions to upward range trends.
- (2) It is recommended that YOSE-N-1a be continued as an annual investigation, required for the proper management of deer in a "natural area." Continuation of the program should include:
- (a) revision of the present range survey field form to meet statistical analysis requirements.
  - (b) continued reconnaissance of summer ranges to delineate and designate key browse areas.
  - (c) establishment of additional permanent range transects.
  - (d) maintenance of deer exclosures.
  - (e) establishment of permanent photo reference transect points.
  - (f) statistical analysis of transect data.
  - (g) investigation of possible wintering areas within the park and their potential carrying capacities.
  - (h) development of a census technique which will provide a reliable index to deer population levels occupying strategic summer ranges.
  - (i) monitoring and evaluating the response of deer herds to the in-park prescribed burning programs.

# # #

PRESERVATION OF THE PIUTE CUTTHROAT TROUT  
YOSE-N-7

INVESTIGATOR: Terry Mills  
California State Department of Fish and Game

SUMMARY OF PROGRESS: Piute cutthroat trout were introduced into Delaney Creek in 1966 to protect and preserve this unique native California trout. This population was also to serve as a source of Piutes for further introductions into barren Sierra streams. In 1972, 77 Piutes from the Delaney Creek population were introduced into Stairway Creek, Madera County. That introduction will be checked in 1974. Also, Sharktooth Creek, Fresno County, is scheduled to be stocked with Piutes in 1974.

A 2-day survey of Delaney Creek during October 1973 revealed that the Delaney Creek population had dwindled from an estimated 300 fish per mile in 1971 to an estimated 75 fish per mile in 1973. The reason for this reduction was the presence of approximately 300 eastern brook trout per mile which also inhabit the Delaney Creek drainage. During the 2-day survey, electrofished brook trout were removed. The following is a summary of the survey:

	<u>Cutthroat Piute</u>	<u>Eastern Brook</u>
Upper Meadow	58	367
Between Meadows	41	204
Lower Meadows	<u>45</u>	<u>333</u>
	144	904

Future plans for the Piutes in Delaney Creek include electrofishing surveys to remove brook trout and if the population improves, remove enough Piutes for an introduction into Sharktooth Creek.

MERCED PEAK  
YOSE-N-11a

INVESTIGATOR: Dallas L. Peck  
U.S. Geological Survey

SUMMARY OF PROGRESS: Geologic study of the Merced Peak and Yosemite quadrangles leading to publication of a geologic map of each quadrangle at a scale of 1:62,500 and separate publication of analytical data and special topics. The project was recessed from 1963 to 1966, while the project chief was stationed in Hawaii, and was largely inactive from 1966 to 1971, when he was engaged in administrative work.

Geologic mapping of the Merced Peak quadrangle has been completed and has resulted in the publication of a preliminary map (U.S. Geol. Survey MF-281). Mapping of the Yosemite quadrangle is about one-quarter complete.

The Yosemite and Merced Peak quadrangles across the Sierra Nevada batholith from the western metamorphic belt to the Ritter Range pendant along a belt underlain by abundant metamorphic rocks and small intrusive bodies. The metamorphics are largely massive silicic tuffs in the eastern part of the area, and micaceous quartzites in the west. The intrusive rocks include large zoned granitic plutons of the Tuolumne and older series (including Sentinel grandiorite), but in contrast to most of the batholith elsewhere include abundant small granitic and dioritic plutons intimately associated with the metamorphic rocks. The rocks are broken along several northwest-trending distributive shear zones, each 5 miles or more in length and 1-2 miles wide; individual shears trend parallel to the zones and dip east and west, and lineations in the plane of the shears bear consistently northeast.

# # #

GEOLOGY OF THE TUOLUMNE MEADOWS QUADRANGLE  
YOSE-N-11a

INVESTIGATORS: Paul C. Bateman, Dallas Peck )  
Ronald Kistler, John Lockwood ) U.S. Geological Survey  
Bruce Chappell ) Australian National University

SUMMARY OF PROGRESS: Geology study of the Tuolumne Meadows quadrangle will result in a geologic map, at a scale of 1:62,500, and a separate publication giving analytic data for the quadrangle. These publications will be similar to ones already published on quadrangles to the south--for example, the Huntington Lake and Kaiser Peak quadrangles. They are part of a broad study of the basement rocks across the Sierra Nevada between the 37th and 38th parallels.

In addition, Bateman and Chappell have begun a detailed study of compositional variations along the Tioga Pass Road.

All the investigators are engaged in other work and contribute to the study of the Tuolumne Meadows quadrangle as time permits. Thus, no firm schedule is possible.

LOGEPOLE NEEDLE MINER  
YOSE-N-30

INVESTIGATOR: Thomas W. Koerber  
Pacific Southwest Forest and Range Experiment Station

SUMMARY OF A detailed understanding of the ecological factors regulating the population  
PROGRESS: density of the lodgepole needle miner has been developed. Consequently,  
the needle miner is the only insect whose impact on the forest can now be  
predicted 2 years in advance.

SIGNIFICANT In the face of generally unfavorable conditions, high needle miner popu-  
FINDINGS: lations persist in certain sheltered valleys and basins. These areas are  
slightly warmer than the surrounding area, sheltered from wind, and have  
a lower incidence of violent summer storms. Winter temperatures of -28°F cause heavy  
mortality of needle miners. With certain exceptions, lodgepole forest killed by the needle  
miner are replaced over a long period of time by new forests composed almost entirely of  
lodgepole pine. The net effect is to change stand structural from uneven age to even age.  
Repeated epidemics together with the slow growth rates of the high elevation forests can  
keep the forest in a permanent juvenile thicket stage.

RECOMMENDATIONS: As a result of changes in park service policy and discussions held last  
spring, the project as originally conceived will not be completed. It is  
recommended that the work be reoriented and reduced.

The lodgepole needle miner population in Yosemite Park presents a unique opportunity to  
study the interactions between a large-scale defoliator and environmental factors un-  
hindered by pest control or timber salvage operations. Anywhere except in a large national  
park there would be efforts to reduce the insect population and/or salvage the dead trees.  
For the time being, we would like to continue to monitor the needle miner population and  
its effects on the forest to improve our understanding of the basic ecological processes  
involved. I would hope that with continued public interest in ecology the information  
produced would be a considerable value to the park's interpretive program.

# # #

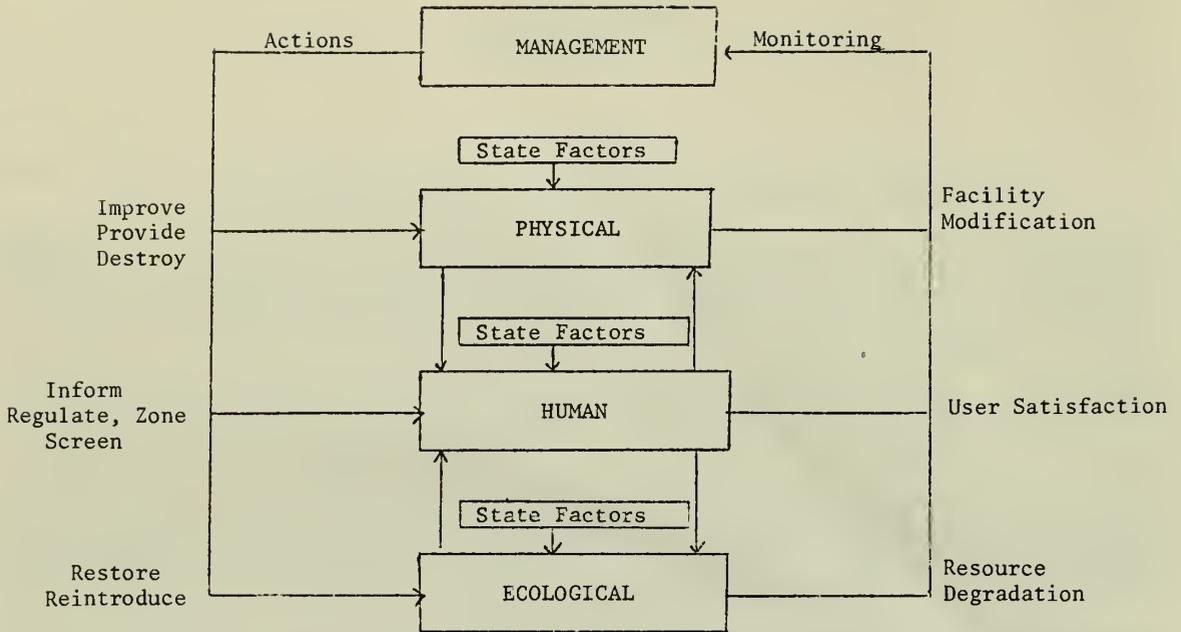
BACKCOUNTRY CARRYING CAPACITIES FOR YOSEMITE NATIONAL PARK

INVESTIGATOR: Jan W. van Wagtenonk

OBJECTIVES: To determine carrying capacities for the backcountry based on physical,  
ecological, and human factors.

METHODS: This project will synthesize present knowledge, concurrent studies, and the  
results of original research in deficient areas to develop a model capable  
of sophisticated computer simulation of a large array of situations. Output from the model  
will include not only carrying capacity figures but also descriptive data of current con-  
ditions and predictive data concerning the ecological ramifications of management decisions.

RESULTS AND Concurrent studies conducted during 1973 include research by Dr. Robert G.  
DISCUSSION: Lee on the management of human components of the park's ecosystems, by  
Dr. Theodore C. Foin on ecological processes in relation to human use, and  
by Mr. Rexford Palmer on trail revegetation methods. A conceptual carrying capacity model  
is being developed which will incorporate the results of these studies as well as studies  
to be initiated in 1974. This model is represented below:



The model consists of differential equations of the general form:

$$d(P, H, E)/dt = f(P, H, E, M, \text{state factors}),$$

where changes in the components with time, as measured by facility modification, user satisfaction, and resource degradation, are functions of management actions, component relationships, and state factors. These changes are in turn monitored by management to determine if they exceed acceptable limits. As an acceptable limit is approached, the carrying capacity is also reached.

PLANS FOR  
1974:

The conceptual model will be developed more fully with particular emphasis on the identification of sensitive relationships which would need quantification. New studies will be initiated to investigate those relationships.

For 1974, contracts will be let for research on campsite and trail impacts, human-mammal interactions, and meadow inventory data.

Publication:

Publications are planned for specific subprojects as well as for the development of the conceptual model. No time frame can be given at this time.

###

#### ANATOMICAL AND BIOLOGICAL STUDY OF THE MONOTROPOIDEAE (ERICACEDE)

INVESTIGATOR: Gary D. Wallace  
Claremont Graduate School

SUMMARY OF  
PROGRESS: Preliminary studies and material for anatomical studies essentially complete. Further studies over a period of years required for study of ecological relations, pollination biology, seed dispersal, and possible epiparasitic relationships. Cytological data are required as well. I hope to carry on these studies

over a period of years.

I would appreciate notification of exact localities for the following rare species and plead for their being left entirely alone because they are very rare in the Sierra Nevada: *Pityopus californicus*, *Hemitomes congestum*, *Pleuricospora fimbriolata*.

# # #

#### VISITOR USE OF THE YOSEMITE VALLEY SHUTTLEBUS SYSTEM

INVESTIGATOR: Allan W. Wicker  
Claremont Graduate School

SUMMARY OF PROGRESS: Work to date has involved collecting information from research reports, casual observation, and interviews with National Park Service staff related to the large numbers of users of Yosemite Valley. This information is being used to plan a systematic investigation of visitor use of the valley shuttlebus system, to be conducted in the summer of 1974.

# # #

#### DETERMINATION OF BIOLOGICAL DISCRIMINATION FACTORS FOR METALS WITHIN NATURAL ECOSYSTEMS

INVESTIGATOR: Claire C. Patterson  
California Institute of Technology

SUMMARY OF PROGRESS: A study was made of seven metals [(K,Rb,Cs), (Ca,Sr,Ba), and Pb] that are either nutritious or toxic in rocks, minerals, soil, snow, water, soil moisture, plants, and voles which composed an ecological system in a remote canyon in the High Sierra. Precise analytical methods, using mass spectrometric isotope dilution techniques, were developed for the analysis of these metals.

Most of the lead contained in sedge and voles (mountain meadow mice) within one of the most pristine, remote valleys in the United States is not natural, but came from smelter fumes and gasoline exhausts. In a food chain, lead was systematically excluded from nutritious calcium at successive trophic levels by an overall factor of 200 in proceeding from rock, to soil moisture, to sedge, to vole. This factor would have been greater than 1000 if lead aerosols had not collected on sedge leaves and circumvented the tendency by sedge to exclude lead from the nutritious metals it absorbed from soil moisture.

Balance data showed that there was a net loss of Ca and Sr from the canyon via streams but that these losses per unit area per year were one-sixth to one-third of the amounts of Ca observed to be lost in studies of four other closed basins by other investigators. Contrary to interpretations made in other closed basin studies, balances for other metals such as K were overshadowed by the masses of metals swirled in and out of the canyon in locally derived dusts.

Compositions were determined of true soil moisture taken from undisturbed natural soils by means of filter paper. The K/Ca ratio in this true moisture was found to be 4, which was identical to that found in sedge whose roots were exposed to the soil moisture. The K/Ca ratio in a "soil solution" prepared from distilled water and a dried portion of the identical soil using the accepted standard laboratory method was 0.5. It was also found

that the reservoirs of K and Ca in true soil moisture are about equal to the amounts of these metals consumed in yearly sedge production.

We have received informal notification from the NSF that our CIT project in Yosemite will be funded for 2 more years with informal assurance that funding for 2 or 3 more years is probable. During this time our major research objectives in Thompson Canyon would include:

- A. Characterization of changes in metal contents of the humus fraction of soil with aging.
- B. Chemical relationships among soil moisture, humus, and plants as a function of season, plant maturity, and plant species.
- C. Investigation of metal discriminations in a predator belonging to the vole food chain.
- D. Development of the techniques for Sn, Ge, Ga, In, Tl, Cu, An, Au, and their application to materials from Thompson Canyon.

# # #

#### TRAIL REVEGETATION STUDY

INVESTIGATOR: Rexford E. Palmer

SUMMARY OF PROGRESS: Approximately 18 different revegetation techniques were tried during the summer of 1973. Observations of their effectiveness will be made during summer 1974.

Proposal for 1974 research is now being prepared and will be submitted to the park biologist upon completion.

# # #

#### *FOMES ANNOSUS*: DETECTION AND EVALUATION IN YOSEMITE NATIONAL PARK

INVESTIGATOR: John R. Parmeter, Jr.  
University of California, Berkeley

SUMMARY OF PROGRESS: We are continuing to monitor spread and mortality in some 80 root-disease centers. These data will give us the information we need to project future losses and aid the National Park Service in anticipating future conditions in developed sites. We are also continuing to locate new disease centers.

Within the year, we expect to provide the park with a detailed evaluation of each disease center, its probable rate of spread, and what steps might be taken to minimize hazard and loss.

We expect to continue monitoring these plots for at least 10 years in order to increase the precision with which we can project rates of center initiation, spread, and damage.

## THE EFFECT OF THE ENVIRONMENT ON DYSLEXIA AND HYPERACTIVITY IN CHILDREN

INVESTIGATOR: Henry W. Munroe  
New Hampshire College and University Council

SUMMARY OF PROGRESS: Basic journal data compiled on backpacking trips in Yosemite during summer of 1973. First phase ran with reduced amounts of Ritalin being administered to the child. Findings indicate the child can effectively cope with learning techniques when not encumbered by normal educational atmosphere (classroom both structured and open). Second phase will repeat same control and testing techniques with no drug use during the summer of 1974.

Data to be developed with Dartmouth Mental Health Center winter of 1975. Hopefully, a monograph produced in simplified form that can be utilized as a parent handbook.

# # #

## CHEMICAL INVESTIGATION OF HIGH SIERRA PLANTS

INVESTIGATOR: John E. Mc Murry  
University of California, Santa Cruz

SUMMARY OF PROGRESS: Our research has involved the collection and extraction of various High Sierra plants, particularly wildflowers, in a search for new natural products with medicinal properties. This past year, we have examined two species, *Sarcodes sanguinea* (snow plant) and *Ipomopsis aggregata* (scarlet gilia), both collected near the Clark Fork of the Illilouette.

After separation of the crude extracts into fractions by a solvent partitioning scheme, the fractions are sent to the National Cancer Institute for testing. Further purification of the fractions into pure compounds is then carried out by chromatography, and the pure compounds are then sent to Merck, Sharp and Dohme for broad spectrum biological testing. The testing process is quite time consuming, and it is too early for results yet.

We plan to continue the work for quite some time in view of the many species which are available and yet unexamined.

# # #

## ANALYSIS OF ECOLOGICAL PROCESSES IN RELATION TO HUMAN USE OF THE PARK

INVESTIGATOR: T. C. Foin  
University of California, Davis

SUMMARY OF PROGRESS: We analyzed four sites of Yosemite Valley: the conifer forests of the Cathedral and Iron Springs areas; Ahwanee Meadow; and Stoneman Meadow (late June - early August). Since our data indicated human use impacts less than we expected, we spent the remainder of the time (August - mid-September) at Tuolumne Meadows, where we analyzed three sites: Dana Meadows, lodgepole pine forest and the meadow beneath Lembert Dome, and the campground lodge pole forest.

All seven sites were subject to a routine analysis for mammal populations, birds, soil structure and composition, floral structure, visitor use, and effects of management.

# # #

#### INSECTS AND OTHER ARTHROPODS FOUND ON SNOW FIELDS

INVESTIGATOR: David Durbin  
California State University, San Francisco

SUMMARY OF My research has been progressing quite satisfactorily. I have found some  
PROGRESS: very interesting insects in Yosemite National Park, but until expert identification I cannot detail these discoveries.

This research is being conducted as partial fulfillment of a masters degree. I expect to finish writing my thesis by June or at the latest December 1974. At this time I intend to submit either a detailed research report or a copy of my masters thesis.

# # #

#### GYPSY MOTH (*PORHETRIA DISPAR*) SURVEY

INVESTIGATOR: Richard L. Dunkle  
California Department of Food and Agriculture

SUMMARY OF The Gypsy Moth (*Porthetria dispar*) is a serious pest of forest, shade, and  
PROGRESS: fruit trees in the eastern United States. This moth is constantly being transported into California by means of tourists, movers, truckers, etc., who come into California from infested areas in the east. Egg masses are laid on or in vehicles or belongings such as toys, garden and lawn furniture, or other outdoor equipment, and are subsequently brought into California.

The state of California traps for the gypsy moth at the county level on an annual basis, deploying over 5000 traps each season. This pest does not yet occur in California; the purpose of our trapping program is to detect the moth if it does get in. Yosemite Park is considered a high hazard area due to the tremendous annual influx of tourists. During the 1973 season, 41 traps were placed throughout the park and were serviced twice a month from June through September. It is hoped that we can continue this indefinitely on an annual basis. We also hope to distribute posters and leaflets of the gypsy moth throughout the park in order to inform and involve the public. We sincerely appreciate your cooperation in our efforts to keep this serious pest out of California.

SYSTEMATICS AND NATURAL HISTORY OF THE MYGALOMORPH SPIDERS GENUS  
*ALIATYPUS* (ARANEAE: ANTRDIAETIDAE)

INVESTIGATOR: Frederick A. Coyle  
Western Carolina University

SUMMARY OF At least one species of *Aliatypus*, as yet undescribed, is present in the  
PROGRESS: park. It is rather common as high as 8000 ft in the red fir forests. Most  
other species of *Aliatypus* are restricted to the drier Mediterranean climates  
of the lower parts of central and southern California. *Aliatypus* is a species of trapdoor  
spiders.

# # #

GEOLOGY OF THE SADDLEBAG LAKE ROOF PENDANT

INVESTIGATOR: Charles Brook  
University of California, Santa Barbara

SUMMARY OF At present, this investigation is primarily concerned with the deformational  
PROGRESS: history of the metamorphic rocks in the Saddlebag Lake roof pendant. Only  
a very small part of this pendant lies within park boundaries, and mapping  
of that part has essentially been completed. Metamorphic rocks occurring within park  
boundaries are correlative with metamorphic rocks on Mount Dana and consist of two multiply  
deformed sequences - a Silurian(?) - Ordovician(?) metasedimentary sequence and a Permian  
metavolcanic sequence. Of particular significance (at least to me) was the discovery of a  
relatively major fault bounding the eastern flank of Gaylor Peak. This helped to clarify  
the structural geometry of rocks outside the park. Also, several smaller faults were  
found in the vicinity of the Great Sierra Mine. These faults occur only in the meta-  
morphorphic rocks, and as such, they are pre-batholithic (pre-Late Cretaceous) and have pro-  
bably been inactive for a least 125 million years. A preliminary geologic map of the area  
will be sent on request.

# # #

STUDIES OF GENETIC VARIATION IN *RANA BOYLEI* AND *RANA MUSCOSA*

INVESTIGATOR: Susan M. Case  
University of California, Berkeley

SUMMARY OF Although the two frogs *Rana boylei* and *R. muscosa* are generally recognized  
PROGRESS: as biological species, there has been some question about the validity of  
taxa. In fact, *R. muscosa* may represent several cryptic species, each  
restricted to a single drainage system in the high elevations of the Sierra Nevada. Each  
high elevation population would have evolved from the low elevation populations of *R. boylei*  
in that drainage system. This hypothesis would predict that *R. muscosa* from one drainage  
system should be more closely related genetically to *R. boylei* populations of that drainage  
system than to *R. muscosa* populations from other drainage systems. I have been attempting  
to test this hypothesis by studying gross and fine chromosome morphology and protein vari-  
ation of populations in several drainage systems throughout northern California. To date,

only the electrophoretic study of protein study of protein variation has been completed; gross chromosome morphology has been examined and studies of fine structure using C and G bands are currently in progress.

Karyotype analysis confirms the work of Houser and Sutton (1969). Both species have  $2n = 26$  with chromosomes divided into two classes: 5 pairs of large and 8 pairs of small elements. The larger elements are identical in the two species and consist of 2 pairs of metacentrics and 3 pairs of submetacentrics. Of the smaller elements, *R. boylei* possesses 8 pairs of submetacentrics while *R. muscosa* has 2 pairs of metacentrics, 3 pairs of submetacentrics, and 3 pairs of acrocentrics. There does not seem to be any variation in the gross morphology in different drainage systems in either species.

Populations of *R. boylei* from Colusa, Trinity, Nevada, and Tuolumne counties, and *R. muscosa* from Nevada and Tuolumne counties (including 10 from Yosemite Nat'l Park) were examined electrophoretically. Ten enzymes, representing 16 loci, were scored, except in the Tuolumne county populations in which only 5 loci were scored. Gene frequencies for each locus were calculated; the proportions of phenotypes observed did not seem to differ significantly from the Hardy-Weinburg equilibrium. Coefficients of genic similarity were calculated for pairs of populations. The *R. boylei* populations all showed high degrees of genic similarity as did the two *R. muscosa* populations (coefficient of genic similarity 0.9 or greater). However, the comparisons of *boylei* and *muscosa* populations revealed low degrees of genic similarity, regardless of whether or not they were from the same drainage system. These results would tend to support the idea of two distinct species, one occurring at high elevations the other, at low elevations.

## ZION NATIONAL PARK

### BIGHORN SHEEP RESTORATION PROJECT ZION-N-0002

**SUMMARY OF PROGRESS:** Due to the untimely deaths of Robert D. Metherell and Charles Hansen, there are no researchers assigned to this project at this time. Park personnel are keeping track of the transplanted sheep in the compound. A resident biologist will be moving to the park sometime early in 1974 and will take charge of the project.

On 13 July 1973, 10 sheep (1 ram, 9 ewes) were transplanted from Lake Mead Recreation Area to Zion National Park. Two more rams were brought in from Nevada on 23 August 1973. One young female died of malnutrition on 20 August, another young female died of unknown causes on 29 September. Since then one lamb was born on 16 December, and another on 25 December. A feeding program was initiated in early October on the recommendation of Jack Cooper of the Nevada Fish and Game Department. This consists of a grain mix of 100 lbs. cracked corn, 120 lbs. rolled oats, and 50 lbs. commercial calf pellets, and the best grade of alfalfa hay.

ECO-BEHAVIORAL COMPARISONS OF RINGTAILS AND GRAY FOXES  
ZION-N-0005a

INVESTIGATOR: Gene R. Trapp  
University of Wisconsin

SUMMARY OF PROGRESS: The Ph.D. thesis has been completed and the degree received. A copy of the thesis was submitted to the Zion Natural History Association. Should the National Park Service desire a copy, they should inquire with the Executive Secretary of the Association at Zion. A paper comparing home range and habitat utilization of the two study species was delivered at the annual meeting of the American Society of Mammalogists (this year at Pacific Grove, Ca.). The main body of the thesis will be published in a scholarly journal soon, as will various "extras" or "spinoffs" picked up while doing the project.

# # #

RANGE SITE-SOILS CORRELATION  
ZION-N-0017

INVESTIGATOR: Lamar R. Mason  
USDA, Soil Conservation Service

SUMMARY OF PROGRESS: During 1973, the 8th year of our 10-year study in Zion National Park we completed range yield studies in five different locations: (1) Southeast corner of park, (2) Checkerboard Mesa, (3) near Sawmill Spring, (4) Deer Trap Mountain, and (5) near Stevens Wash.

During our remaining 2 years we would like to make studies as follows:

(1974)

1. 20 plots East side of West Rim Trail near West Central part S 32, T 40 S, R 10 W.
2. 20 plots NE of fork in trail near center of S 29, T 40 S, R 10 W.
3. 20 plots between the 2 trails in SW $\frac{1}{4}$  S 32, T 40 S, R 10 W.
4. 20 plots about 200 yards north of where trail crosses draw in west central part of S 33, T 40 S, R 10 W.

(1975)

1. 20 plots W $\frac{2}{2}$  S 24, T 41 S, R 11 W near Scoggins Wash.
2. 20 plots N $\frac{2}{2}$  S 36, T 41 S, R 11 W east of Huber Wash.
3. 10 plots East of road S $\frac{2}{2}$  S 7, T 40 S, R 10 W.
1. 20 plots East of road NE $\frac{4}{4}$  S 18, T 40 S, R 10 W.
- 20 plots West of road near center of S 31, T 39 S, R 10 W.

# NATIONAL PARK SERVICE SCIENCE CENTER

## 1. SERVICE-WIDE STUDIES

### a. NATIONAL PARK TRAILS (PART I)

INVESTIGATOR: Lennon W. Hooper  
Denver Service Center

SUMMARY OF PROGRESS: An analytical report on trails in areas of the National Park System. The purpose of this study was threefold: first, to analyze existing trails in the National Park System; second, to recommend changes needed both for intrinsic improvement and for integration purposes; third, to formulate criteria for trail planning applicable to all park and nonpark trails in a broad range of settings.

The method used to obtain the information was by a questionnaire, which was sorted by regions, and then coded in accordance with the National Park Service coding system. The data was card-punched, and the computer program was written.

Copies of this report were sent to all parks. This report was published by the Denver Service Center.

# # #

### b. SOIL WATER-REPELLENCY STUDY

INVESTIGATORS: Dennis B. Fenn )  
G. Jay Gogue ) National Park Service Science Center  
Donald E. Gardner)

OBJECTIVES: To determine the potentiality of water-repellency problems in our national park campgrounds and to determine the substances responsible for causing soil water-repellency.

METHODS: Leaf litter from beneath slash pine and water oak as well as a mixture of the two was gathered and air dried. Samples of the leaf litter were then placed on soil columns 12 inches in diameter and 15 inches long and burned. The degree of water-repellency developed in the soil by the burned litter was measured by the time it takes a small water drop to penetrate the soil surface (WDPT).

Clean quartz sand was acid washed, air dried, and sieved through a 30-mesh sieve to remove the larger sand grains. This sand will be divided into 100-g samples, inoculated with selected microorganisms known to cause water-repellency, and allowed to incubate for 45 days. A 0.50% glucose and 0.13% glycine solution will serve as the energy source for fungal growth in the sterilized sand. The sand will then be extracted with selected organic solvents and fractionated by column chromatography and the isolates analyzed by mass spectrometry, gas chromatography, infrared spectrophotometry, and UV-visible spectrophotometry in an effort to identify the organic constituents causing the microbially induced water-repellency.

RESULTS AND DISCUSSION: Studies completed to date have shown that water oak leaf litter and pine needle litter do impart water-repellency to sandy soil upon burning if the temperature of the burn is not too high. Where charcoal was placed on top of the litter and burned, no water-repellency was found. Where the leaf litter alone was ignited and burned, definite water-repellency was noted, with a standard water droplet remaining on the surface indefinitely without penetrating the soil. When the fire is too hot,

the organic vapors emanating from the leaves are evidently completely oxidized and consumed. At lower temperatures some of these substances condense out of the sand grains and form a hydrophobic coating, causing the soil to exhibit this water-repellent phenomenon. Water-repellency can be an important factor in soil erosion. If a soil is water-repellent, runoff will be higher, thereby increasing the erosion potential.

PLANS FOR 1974: The experiment will be completed. The fungal cultures have been ordered and this phase of the experiment will begin early in 1974. The optimum temperatures for creating fire-induced water-repellency will also be studied in the laboratory.

# # #

### c. SOIL TEMPERATURES UNDER CAMPFIRES

INVESTIGATORS: Dennis B. Fenn)  
G. Jay Gogue ) National Park Service Science Center

OBJECTIVES: To determine what range of temperatures are generated within the soil profile under a campfire. Factors such as maximum temperatures reached at various depths in the soil, effect of residual soil moisture on the temperature profile, soil texture and duration of the campfire burn will be studied and determined.

METHODS: Chromel-alumel thermocouples, 1/16 inch in diameter and 12 inches long, were interfaced with a millivolt pot to determine the temperature in the soil profile.

Laboratory studies were conducted using a stainless steel cylinder 12 inches in diameter and 15 inches long. The thermocouples were inserted into the side of the cylinder wall through small holes drilled at selected depths ranging from the soil surface to 13 cm below the surface. The tips of the thermocouples were aligned at the center of the cylinder. The correct depth and alignment of the thermocouples were maintained by inserting the thermocouples through small holes in a thin, stiff strip of asbestos. This asbestos strip was mounted 2 inches from the center of the cylinder. The cylinder was filled with a desired soil after inserting the thermocouples and the soil was then lightly compacted by striking the cylinder wall several times with a small hammer.

Laboratory experimental burns were conducted using 5 pounds of commercial charcoal as the fuel. This simulates a common type of cooking fire used in many large campgrounds. Field studies will be conducted using firewood as well as charcoal for fuel.

RESULTS AND DISCUSSIONS: Preliminary studies have shown several interesting results. The initial studies were carried out using a millivolt pot detector, but the inadequacy of this system was soon apparent since it did not allow us to continually monitor the soil temperature over the total burn time. Only point measurements could be made with the millivolt pot. A system was designed to automatically record the temperatures with a multichannel strip chart recorder over the entire burn time. The data reported here were made with the millivolt pot only.

Table 1 shows the results of laboratory tests with a charcoal fire on several soil textures. In all four soils, the 8-hour reading was the maximum reading up to that point in the burn. The kaolinite clay reached a temperature of 690°C at the surface while the coarse sand was much cooler, reaching only 460°C in 7 hours. The kaolinite clay gets hotter than the other soil textures at all depths measured, and as can be seen from the 24-hour temperatures in Table 1, it holds the heat longer than the coarse textured soils.

PLANS FOR  
1974:

The multichannel, continuous recording instrument has now been constructed and experiments are under way to refine, expand, and complete this study and accomplish the experimental objectives outlined above. This study will be completed in early 1974.

Table 1. Soil temperatures ( $^{\circ}$  C) at various times after ignition and at several depths (cm) in the soil during a laboratory campfire with 5 pounds of charcoal.

Soil Texture	Hours After Ignition	Thermocouple Depth in Soil						
		0	1.5	2.5	5	8	10	13
Sandy loam	0	10	10	10	10	10	10	11
	8	570	455	395	300	215	155	105
	24	---	---	---	---	---	---	---
Fine sand	0	14	14	14	12	12	12	11
	8	540	460	370	295	210	170	115
	24	48	52	54	55	54	52	47
Coarse sand	0	22	24	25	26	26	25	26
	8	460	385	125	215	145	175	80
	24	220	240	120	170	145	150	95
Kaolinite clay	0	21	21	21	20	20	20	20
	8	690	670	685	425	295	180	150
	24	100	135	135	240	255	240	230

## 2. PARK STUDIES

### a. CARLSBAD CAVERNS NATIONAL PARK

#### MICROORGANISM SURVEY IN SOIL AND DEBRIS FROM CARLSBAD CAVERNS

INVESTIGATOR: Donald E. Gardner  
National Park Service Science Center

p. 38

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### b. EVERGLADES NATIONAL PARK

#### GEIGER TREE PROPAGATION

INVESTIGATOR: G. Jay Gogue )  
Dennis B. Fenn) National Park Service Science Center

p. 63

ENCROACHMENT OF EXOTIC PLANTS IN EVERGLADES NATIONAL PARK

INVESTIGATORS: G. Jay Gogue )  
Clyde J. Hurst) National Park Service Science Center p. 63  
Dennis B. Fenn)

# # #

c. GREAT SMOKY MOUNTAINS NATIONAL PARK  
ANAKEESTA ACID POLLUTION STUDY

INVESTIGATOR: Dennis B. Fenn  
National Park Service Science Center p. 142

MIMOSA WILT: CONTROL OF PLANTS THROUGH NATURAL DISEASE

INVESTIGATOR: Donald E. Gardner  
National Park Service Science Center p. 144

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## BIBLIOGRAPHY

- Agee, James K. 1973. Prescribed fire effects on physical and hydrological properties of mixed conifer forest floor and soil. Water Resources Center, University of California, Contr. Report No. 143, 57 p.
- Brook, Charles. 1972. Stratigraphy and superposed deformations of a part of the Saddlebag Lake roof pendant, Sierra Nevada, California. M. A. Thesis. California State University, Fresno.
- Canon, B. Bartlet. 1973. The Holopervasion of the Okanogan, Chelan, and Skegit Trisection. University of Washington. 139 p.
- Cave Research Foundation. 1973. The Flint-Mammoth cave system. Three-color map of cave system on topographic base. One sheet with text on back.
- Cheifetz, E., R. C. Jared, E. R. Giusti, and S. G. Thompson. 1972. Search for superheavy elements in nature. Phys. Rev. 6(4):1348-1361.
- Clague, John, Richard Careaga, and J. H. Birman. 1973. Glacial geology in the Kern Canyon drainage, Sierra Nevada. Final Report to NPS, SKC-N-22.
- Clark, William H., and Peter L. Comanor. 1973. A quantitative examination of spring foraging of *Veromessor pergandei* (Mayr) in northern Death Valley, California (Hymenoptera: Formicidae). Am. Midl. Nat. 90(2):467-474.
- Crowe, Bruce M., and Richard V. Fisher. 1973. Sedimentary structures in base-surge deposits with special reference to cross-bedding, ubehebe craters, Death Valley, California. Geol. Soc. Am. Bull. 84:663-682.
- Dill, D. B., M. D. Yousef, and James D. Nelson. 1973. Responses of men and women to two-hour walks in desert heat. J. Appl. Physiol. 35(2):231-235.
- Dodge, F. C. W. 1971. Al<sub>2</sub>SiO<sub>2</sub> minerals in rocks of the Sierra Nevada and Inyo Mountains, California. Am. Mineralogist 56:1443-1451.
- Dodge, F. C. W. 1972. Trace-element contents of some plutonic rocks of the Sierra Nevada batholith. Geol. Surv. Bull. 1314-F. 13 p.
- Dodge, F. C. W. 1972. Variation of ferrous-ferric ratios in the Central Sierra Nevada batholith, U. S. A. 24th Int. Geol. Congr. p 12-19.
- Douglas, George B., Dorothy B. Naas, and Ralph W. Naas. 1973. New plant records and ranges for Washington. Northwest Sci. 47(2):105-108.
- Douglas, George B. 1973. A preliminary report on revegetation studies at Cascade Pass, Washington. National Park Service Report. 12 p.
- Hansen, Charles G. 1973. Evaluation of burro activity in Death Valley National Monument. Typescript, 43 p.
- Hansen, Charles G. 1972. The evaluation of bighorn habitat in Death Valley National Monument. Typescript, 84 p.
- Heller, H. C. 1971. Altitudinal zonation of chipmunks (*Eutamias*): interspecific aggression. Ecology 52(2):312-319.
- Heller, H. C., and D. M. Gates. 1971. Altitudinal zonation of chipmunks (*Eutamias*): energy budgets. Ecology 52(3):424-433.

## BIBLIOGRAPHY (CONTINUED)

- Heller, H. C., and T. L. Poulson. 1970. Circannian rhythms - II. Endogenous and exogenous factors controlling reproduction and hibernation in chipmunks (*Eutamias*) and ground squirrels (*Spermophilus*). Comp. Biochem. Physiol. 33:357-383.
- Heller, H. C., and T. L. Poulson. 1972. Altitudinal zonation of chipmunks (*Eutamias*): adaptations to aridity and high temperatures. Am. Midl. Nat. 87(2):296-313.
- Hill, Carol A. 1973. Bell Canopies. Natl. Speleol. Soc. News 31:58.
- Hill, Carol A. 1973. Guadalupe cave survey mineralogical report for field trip of 27 May 1973. Report to National Park Service, 5 p.
- Hill, Carol A. 1973. Huntite flowstone in Carlsbad Caverns, New Mexico. Science 181:158-159.
- Hill, Carol A. 1973. Hydromagnesite balloons in Carlsbad Caverns. Natl. Speleol. Soc. News 31:175-176.
- International-Skegit Ross Fishery Committee. 1973. The aquatic environment, fishes, and fishery, Ross Lake and the Canadian Skagit River. Interim Report Vols. I and II. City of Seattle Department of Lighting.
- Johnstone, Donald L., and A. Mark Kubinski. 1973. Survival of intestinal bacteria in pristine waters. Project Completion Report. Washington State University, Pullman, Washington 32 p.
- Jones, David L., and James G. Moore. 1973. Lower Jurassic Ammonite from the southcentral Sierra Nevada, California. J. Res., U. S. Geol. Survey 1:453-458.
- Kilgore, Bruce M. 1972. Impact of prescribed burning on a sequoia-mixed conifer forest. Proc. Tall Timbers Fire Ecology Conf. 12:345-375.
- Kilgore, Bruce M. 1973. The ecological role of fire in Sierran conifer forests, its application to park management. J. Quaternary Res. 3:496-513.
- Lyttle, R. J. 1973. The Yosemite experiments: HF propagation through rock. University of California Rad. Lab. Report 51381. 51 p.
- McLaughlin, John S. 1972. Restoring fire to the environment in Sequoia and Kings Canyon National Parks. Proc. Tall Timbers Fire Ecology Conf. 12:391-395.
- Miller, Joseph W., and Margaret M. Miller. 1973. Revegetation experiments in impacted sub-alpine plant communities at Cascade Pass, North Cascades National Park. Progress Report prepared for National Park Service. 19 p.
- Miller, Joseph W., and Margaret M. Miller. 1973. Succession studies in three wildfire burn sites in the North Cascades National Park service complex. National Park Service Report. 113 p.
- Minckley, Charles O., and James E. Deacon. 1973. Observations on the reproductive cycle of *Cyprinodon diabolis*. Copeia 3:610-613.
- Naiman, Robert J., and Shelby D. Gerking, and Thomas D. Ratcliff. 1973. Thermal environment of a Death Valley pupfish. Copeia 2:366-369.
- Otto, Robert G., and Shelby D. Gerking. 1973 Heat tolerance of a Death Valley pupfish (Genus *Cyprinodon*). Physiol. Zool. 46(1):43-49.

## BIBLIOGRAPHY (CONTINUED)

- Parsons, David J. 1972. The southern extensions of *Tsuga mertensiana* (Mountain Hemlock) in the Sierra Nevada. Madroño 21:536-539.
- Ratliff, Raymond D. 1973. Shorthair meadows in the High Sierra Nevada - An hypothesis of their development. USDA Forest Service Research Note, PSW-281. 4 p.
- Ratliff, Raymond D., and Stanley E. Westfall. 1973. A simple stereophotographic technique for analyzing small plots. J. Range Manage. 26:147-148.
- Rinne, William E., and James E. Deacon. 1973. Fluorescent pigment and immersion stain marking techniques for *Lepidomeda mollispinis* and *Cyprinodon nevadensis*. Trans. Am. Fish. Soc. 102(2):459-462.
- Rowley, J. R., and K. M. Walch. 1972. Recovery of introduced pollen from a mountain glacier stream. Grana 12:146-152.
- Rundel, Philip W. 1973. The relationship between basal fire scars and crown damage in Giant Sequoia. Ecology 54:210-213.
- Schuft, Peter H. 1972. A prescribed burning program for Sequoia and Kings Canyon National Parks. Proc. Tall Timbers Fire Ecology Conf. 12:377-389.
- F.F. Slaney & Co., Ltd. 1973. Environmental investigations, proposed High Ross Reservoir, Canada. Vols. I, II, III, IV, V. City of Seattle Department of Lighting.
- Stitt, Robert R., and William P. Bishop. 1972. Underground wilderness in the Guadalupe escarpment: a concept applied. Natl. Speleol. Soc. Bull. 34:77-78.
- Strand, Steve. 1972. An investigation of the relationship of pack stock to some aspects of meadow ecology for Seven Meadows in Kings Canyon National Park. M.S. Thesis. San Jose State University. 125 p.
- Struble, G. R. 1972. Biology, ecology and control of the lodgepole needle miner. USDA Tech. Bull. 1458. 38 p.
- Thompson, Bernadine. 1973. Concern for environmental problems by campers at North Cascades National Park, Washington. Prepared for Dr. Lynn Robbins, University of Washington, Seattle, Washington. 16 p. + tables and appendix.
- Thornburgh, Dale A. 1973. Survey of recreational impact and management recommendations for the subalpine vegetation at Easy Pass, North Cascades National Park. National Park Service Report. 19 p.
- Yousef, M. K., D. B. Dill, and D. V. Freeland. 1972. Energetic cost of grade walking in man and burro, *Equus asinus*: desert and mountain. J. Appl. Physiol. 33(3):337-340.
- Watson, Richard A. 1972. Review of genetic relationship between caves and landforms in the Mammoth Cave National Park area, A preliminary report by F-D. Miotke and A. N. Palmer. Caves and Karst 14:44-46.
- Watson, Richard A. 1972. Mammoth Cave - a model plan. Natl. Parks and Conserv. Mag. 46(12): 13-18.

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