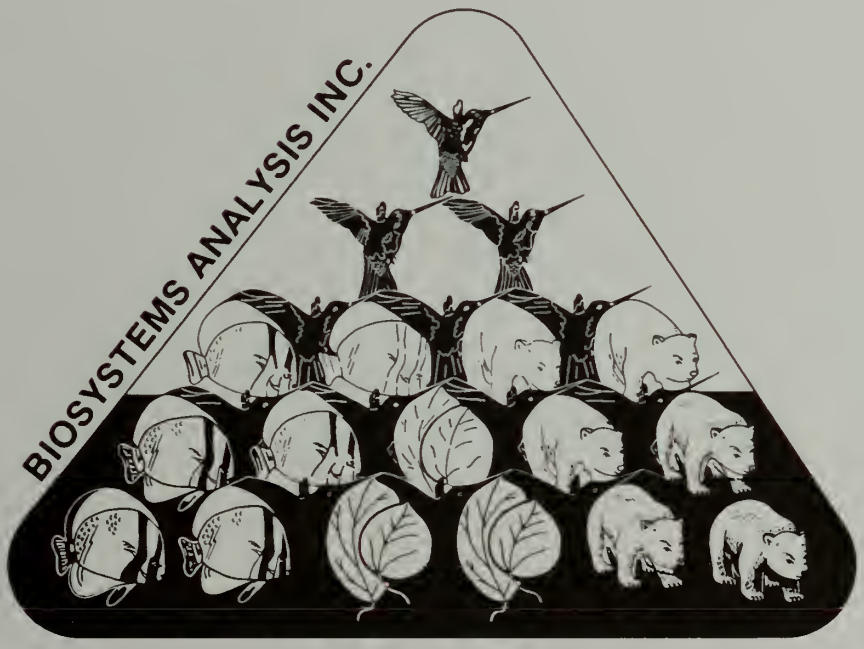
RIPARIAN VEGETATION STUDY ZION NATIONAL PARK, UTAH

-TECHNICAL PROPOSAL-
RFP No. 1200-8-P069



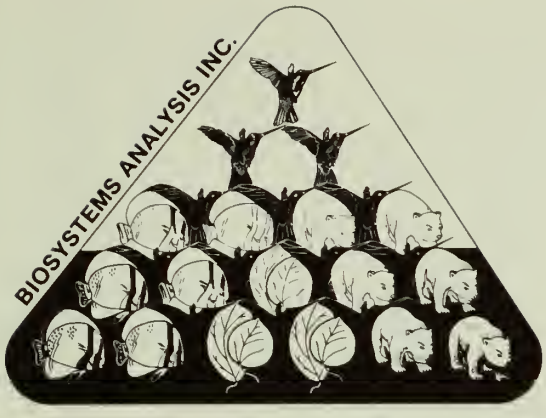
DEPARTMENT OF THE INTERIOR
National Park Service

RIPARIAN VEGETATION STUDY ZION NATIONAL PARK, UTAH

-TECHNICAL PROPOSAL-
RFP No. 1200-8-P069

Proposed by:
BioSystems Analysis, Inc.
303 Potrero St., Ste. 29-203
Santa Cruz, CA 95060

P-717
8 September 1988



8 September 1988

National Park Service
Rocky Mountain Region
P.O. Box 25287
Lakewood, Colorado 80225-0287

Dear Reviewers;

BioSystems Analysis, Inc. is pleased to be able to submit the attached proposal to conduct riparian vegetation studies in Zion National Park, Utah. You will find that we are highly qualified to undertake the required research, and that our work in the ecology of riparian vegetation has been both innovative and extensive.

Should you have any questions regarding our proposal, please do contact me. Litigation over water rights in the west can often be difficult and personally taxing. The United States needs a well-orchestrated case to exert its claim to reserved water rights. Protecting riparian resources should be the primary element on which an adjudication of the Virgin River basin waters is made.

Regardless of the outcome of our proposal, I am most willing to talk with you at length regarding any aspect of riparian ecology.

Sincerely yours;

Dean Wm. Taylor, Ph.D.
Senior Botanist

303 Potrero Street, Suite 29-203, Santa Cruz, CA 95060 • (408) 425-8755

1.0 Introduction

1.0 INTRODUCTION

BioSystems Analysis, Inc. proposes to conduct riparian vegetation studies in Zion National Park to aid the National Park Service and the United States in a general adjudication of water rights within the Virgin River Basin, Utah.

Streams flowing through Zion National Park are subject to hydrologic modification upstream of the Park boundary. A general adjudication of water rights within the Virgin River Basin may result in a change in the existing hydrologic regimen, thus potentially influencing riparian ecosystem structure within the Park. Concern over the potential for negative downstream ecological consequences of changed hydrology provides the basis for the needed studies.

The influence of extrinsic or indirect environmental factors on Park ecosystems has been a recurring theme of concern in the management of National Parks since the 1980 "State of the Parks" report (USDI 1980). In the case of riparian ecosystems within Zion National Park, the problem arises because the Park boundary does not encompass the entire watershed on which riparian ecosystems within the Park are dependent. Consequently, land and resource use practices outside of the Park boundary may have direct consequences on downstream riparian ecosystems. Protection of riparian plant communities within the Park therefore requires information on the potential ecological effects of hydrologic modifications.

1.1 BACKGROUND

Riparian vegetation is that vegetation which occurs along watercourses and is structurally and floristically distinct from nearby, upland vegetation (Campbell and Franklin 1979, Johnson and Lowe 1985). The principal ecological factor controlling structure and composition of riparian vegetation is water. Streams provide supplemental water to riparian plants, even in the most arid of climates (Odum 1979). A second structuring factor of riparian plant communities is fluvial geomorphology: flooding plays a dual role in

removing and regenerating vegetation (Leapold et al. 1964, Hack and Goodlet 1960).

In the western U.S., changing stream hydrology, whether it be flow diversion augmentation or regulation, has often resulted in demonstrable changes in downstream riparian vegetation composition (Williams and Wolman 1984). A generalization can be made regarding the nature of riparian vegetation responses to hydrologic modification: in very arid climates or on small-order streams, streamflow diversion often results in loss of riparian vegetation cover due to drought stress (Taylor 1982). On large-order streams flow diversion is rarely sufficient to totally dewater a stream and thus result in vegetation losses due to drought. Rather, encroachment of dense vegetation in the former active stream channel is a more likely result of hydrologic modification (Williams and Wolman 1984).

In the western U.S., dramatic changes in the nature of riparian habitats have resulted from water resource developments. In the arid southwest in particular, riparian areas function as keystone habitats - influencing diversity far beyond their borders. Recent years have seen an increased level of research interest on southwest riparian systems (Johnson and McCormick 1978, Johnson et al. 1985). Synecological literature on riparian habitats in Utah is only sparsely endowed (Brown 1982, Minckley and Brown 1982, Irving and West 1979).

Predicting the ecological consequences of streamflow modification on riparian vegetation is subject to uncertainty, as is all ecological inference (Hurlbert 1984, Connell and Sousa 1983). Riparian ecosystems are dynamically unstable by their very nature (Odum 1979). As a consequence, understanding the nature of the potential ecological consequences of streamflow modification often becomes a question of defining the threshold level at which change is subjectively judged to be significant. BioSystems botanists have participated in both the basic and applied aspects of riparian vegetation research, and can offer this experience as an aid to the Park Service during adjudication proceedings.

1.2 EVALUATION CRITERIA

The following table lists evaluation criteria as stated in the RFP and the cross reference to appropriate sections of this document.

Criterion	Section
1) Personnel Qualifications	Section 4
2) Response to Scope of Work	Sections 2 & 3
3) Overview and Research Design	Sections 2 & 3
4) Qualifications and Competence	Sections 4-6

2.0 Objectives

2.0 OBJECTIVES

The three objectives for the riparian vegetation study as given in the RFP are restated here:

1) Determine characteristics of existing riparian vegetation within the study reaches.

2) Identify riparian vegetation species and community attributes sensitive to changes in hydrology.

3) Simulate changes in structure, composition and extent of riparian vegetation on the study reaches as a function of altered hydrologic conditions.

2.1 EXISTING RIPARIAN CONDITIONS

BioSystems botanists will provide detailed, quantitative data on the composition of riparian vegetation within the study reaches. Quantification of vegetation composition and structure is necessary to provide a basis for modeling riparian responses to changed hydrology. Systematic vegetation sampling methods will insure objectivity of the data set and will allow for unbiased repeatability in any future resampling. The data base we will assemble will be of sufficient accuracy and detail to be used as evidence in a court of law. We will quantify community attributes such as canopy height and cover that can be used to model expected responses of vertebrate populations (i.e., birds).

2.2 IDENTIFY HYDROLOGICALLY SENSITIVE COMMUNITY ATTRIBUTES

We will analyze riparian vegetation data from the study reaches with direct gradient analysis techniques (Whittaker 1967) and by correlation with substrate conditions (i.e., particle size distribution). Riparian plant species will be ranked in order of their importance (based on cover and frequency). The Riparian Gradient Index position (RGI, see Section 3.0) for each species

will be determined. Stage-discharge curves and channel-cross sections documenting existing conditions will be used to calculate the position of each species with respect to water surface elevation (i.e., frequency of inundation). Specificity or generality of each species with respect to substrate conditions will be determined.

2.3 SIMULATE RESPONSES TO MODIFIED HYDROLOGY

Using information from stage-discharge curves, expected particle size distribution and channel configuration under modified hydrology, we will simulate expected responses of riparian vegetation within the study reaches.

3.0 Technical Approach

3.0 TECHNICAL APPROACH

BioSystems will utilize an existing system of field data collection, data analysis and impact modeling that has been integrated and tested on previous projects. Submitted with this proposal are copies of recent studies we have conducted on riparian plant communities using this approach.

Existing field data forms will be used to record vegetation data (see Appendix B). Data entry and verification procedures, data analysis software, and vegetation response modeling techniques used successfully in previous studies will be employed to study riparian vegetation response to hydrologic modification.

Our experience on similar studies is a direct benefit to the Park Service: we can begin the study in timely fashion, without requiring a costly and time-consuming "gear-up" phase. Utilization of a tested study methodology will allow for efficient and cost-effective conduct of the study. One significant advantage of our approach is that we can collect and analyze the large mass of data necessary to conduct riparian response modeling in a short time period, meeting any scheduling requirements that may arise due to court proceedings.

3.1 DATA COLLECTION

Data will be collected on riparian vegetation using belt-transects oriented perpendicular to the stream. Cover and composition of woody vegetation will be determined using line-intercept sampling (Canfield 1941). Quadrat sampling (Mueller-Dombois and Ellenberg 1974) will be used to determine cover of herbaceous plants. A general channel cross-section will be surveyed at each transect, allowing us to determine the position of each plant with respect to the deepest part of the channel (thalweg). Data on substrate for each tree or shrub and/or within each herb quadrat will be collected (allowing for direct correlation of vegetation features with

hydrologic and geomorphic parameters). Other studies being conducted or contracted by the Park Service will collect additional geomorphic and hydrologic data which will be integrated with the vegetation data.

Transects will be sampled using a measuring tape bisecting the riparian zone. The start and end of each transect will be determined by the limit of fluvial activity (as judged by a combination of geomorphic and vegetation features, including the presence of floated woody debris, erosional or depositional features, moss lines, change from depositional to residual soil, etc.). Data will be encoded as the cumulative distance along the transect (cf. Appendix B). A land-surface elevation profile of each transect accurate to ±2.5 cm will be surveyed using a Leitz automatic level and stadia-rod. A minimum of ten elevation points will be surveyed for each transect, including the water surface elevation at time of sampling, channel width, and elevation of the channel thalweg.

Cover of all woody plants (tree, shrub, vine, etc.) will be recorded along the transect as a vertical projection of the canopy outline (Barbour et al. 1987). Absolute cover and relative cover of each woody plant species will be calculated as the proportion and relative proportion of intercepted distance along the measuring tape, respectively. Cover of herbaceous plants (forbs and graminoids) will be estimated in 1 by 1 meter square-quadrats located at 1-3 meter intervals along the tape. Quadrat spacing will be adjusted to obtain a minimum of 30 quadrats, depending on transect length. Position of initial and successive quadrats will be determined at random. Within each quadrat, all vascular plant species will be recorded, and their cover estimated to the nearest $0.01m^2$. Surficial substrate within each quadrat will be recorded.

Data on rooted position for riparian trees will be collected using a belt transect coincident with each line-intercept transect. Width of the belt transect is anticipated to be 10 meters. Stem diameter, height, rooted substrate and position with respect to the channel (elevation and distance from thalweg) will be recorded or calculated for each tree.

We expect to sample 40 vegetation transects in each stream segment. A vegetation transect will be located coincident with each of the 7-15 transects being established by the Park Service. We will sample supplemental transects in each reach in order to insure adequate sample size, to insure detailed documentation of vegetation composition that will satisfy scrutiny in court, and to provide sufficient observations to quantify riparian gradient position for dominant species for modeling purposes. Supplemental transects will be spaced at a uniform distance upstream and downstream from main transects.

Assuming the study segments are ca. 4,000 feet long, our expected transect spacing would result in a 65 percent sampling of the vegetation in a given segment (at an average of 100 meters between transects).

3.2 DATA ANALYSIS

All field data will be recorded on water-proof paper to insure data integrity (i.e., portable lap top computers or audio recorders will not be used). Data entry and verification will be accomplished upon return to the office. Raw data files will immediately be prepared and be supplied to the NPS (in a variety of MS-DOS microcomputer formats) for use in court proceedings should such data be subject to subpoena or disclosure under discovery.

Data will be analyzed using a variety of univariate, bivariate and multivariate methods (Tukey 1977), where appropriate. Graphic, tabular and narrative summaries of existing vegetation conditions will be prepared for the Preliminary and Final Report. All analyses will be conducted on microcomputers.

3.3 VEGETATION SIMULATION

Riparian Gradient Index - Within the riparian zone, plant species are distributed along an elevation gradient above the channel (streamside to

upland) in relation to their individual tolerances to flooding (Bell 1980, Bell and del Moral 1977), physiological water requirements (Irving and West 1979), and seedling microsite (both substrate and water) requirements (Fenner et al. 1985, McBride and Strahan 1984).

The summation of these responses can be expressed by indexing the relative position of each plant species along the riparian gradient (Figure 3.1).

A Riparian Gradient Position Index can be estimated as:

$$RGI = (RDT + RET) / 2$$

where: RDT = relative distance from thalweg, and
RET = relative elevation above thalweg.

Relativization produces a metric that ranges from 0.0 to 1.0: plants growing within the channel will exhibit Riparian Gradient Position indices in the 0.3-0.5 range, while peripheral species will exhibit indices in the 0.5-0.8 range. Non-obligate riparian or peripheral upland species often have indices >0.7 (Taylor and Davilla 1986).

Using actual data as determined by transect sampling, the RGI is calculated as (refer to Figure 3.1):

$$RGI = \sqrt{A^2 + B^2} / \sqrt{D^2 + E^2}$$

Using the transect data, we will calculate the RGI for each observation of a plant species. Figure 3.2 provides an example of riparian gradient position for three tree species, taken from a previous BioSystems study using this analytical approach (Taylor and Davilla 1986).

Riparian Gradient Position for each species will be an important component of our response simulation (Section 3.4). We will correlate RGI with existing hydrologic data: for example, for each individual plant, the stream discharge

Figure 3.1 Hypothetical riparian cross-section illustrating the determination of Riparian Gradient index (RGI). The index is the relativized distance between the thalweg and the edge of the riparian zone, calculated as the hypotenuse of a right triangle.

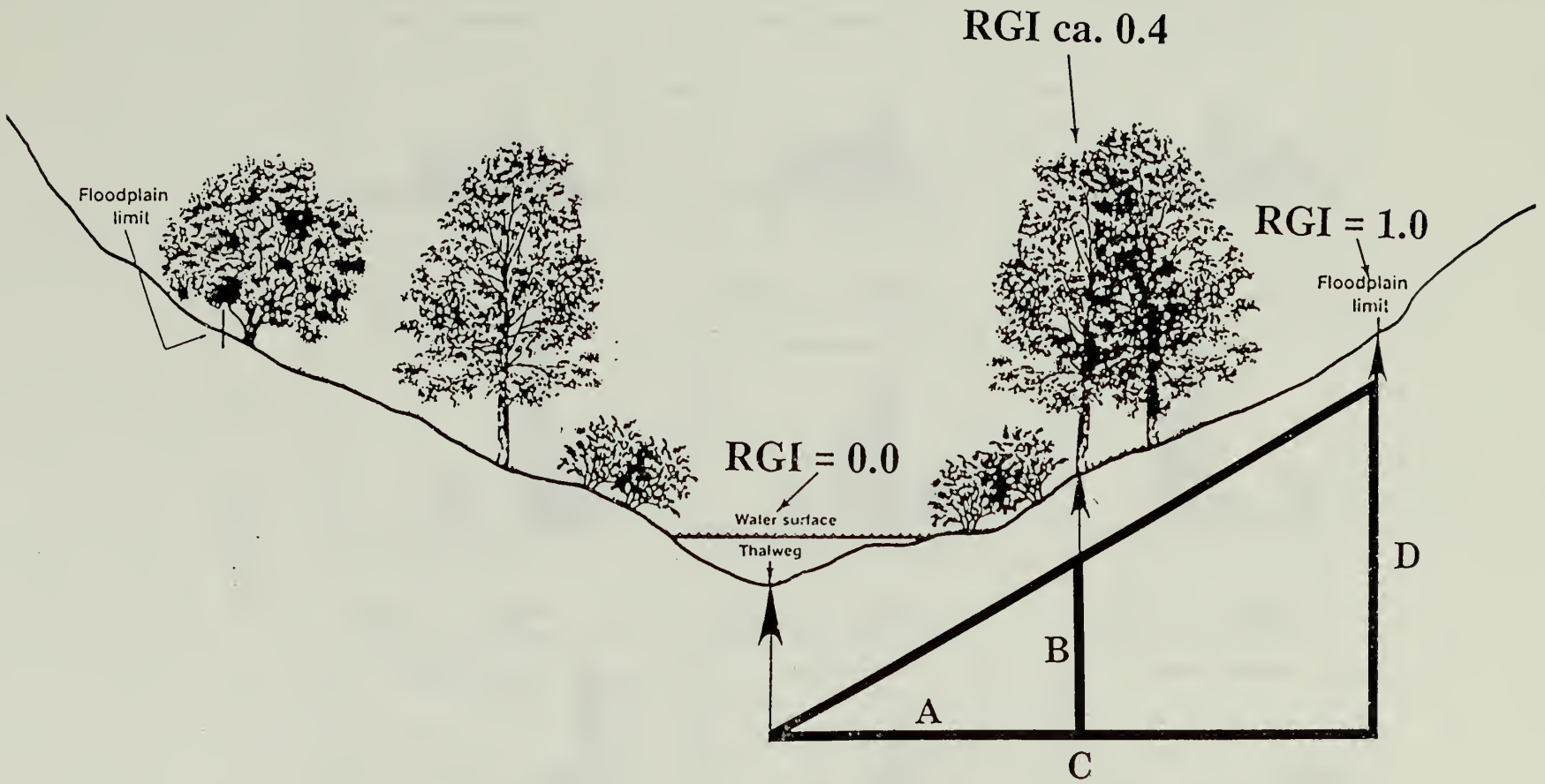
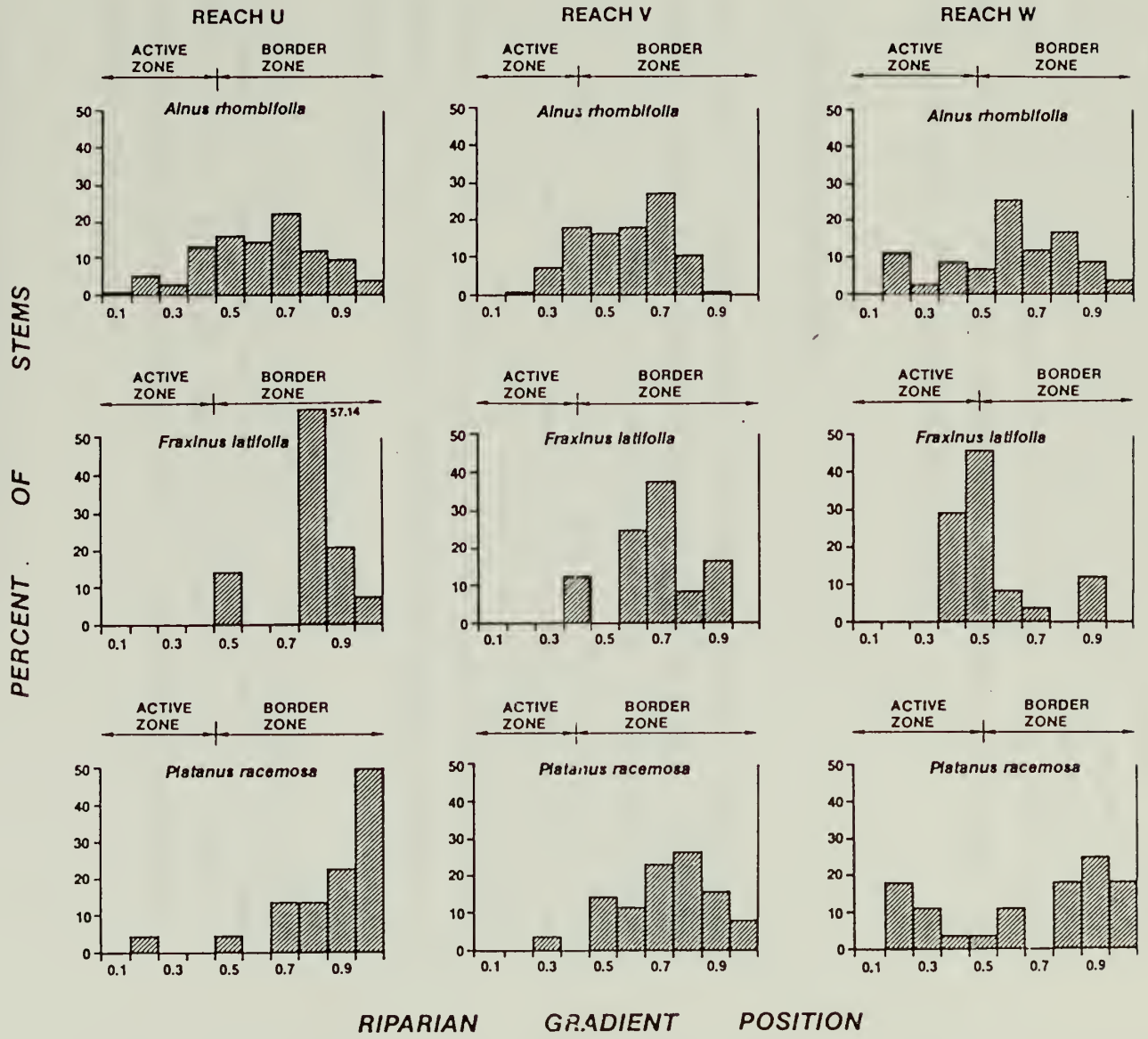


Figure 3.2 Example of Riparian Gradient Index determination for three dominant tree species for the lower North Fork Kings River, California (from Taylor and Davilla 1986). In this example, *Platanus racemosa* is able to grow within the active channel (Active Zone) only in the heavily diverted reach (Reach W).



at which inundation occurs, or the frequency distribution of elevation above the water surface can be calculated using stage-discharge relationships (Dunn and Leapold 1978). Simulating expected changes in riparian vegetation distribution within the riparian continuum will be based on the assumption that modified hydrologic conditions will result in a direct shift in Riparian Gradient Position that is a function of the frequency of expected water surface elevations, modified by surficial substrate requirements. For example, a species that occurs at only at the edge of the active channel might respond to changed hydrology by encroaching the channel as equilibrium with the new discharge regime is reached.

3.4 RESPONSE SIMULATION

Our approach to simulating change in riparian vegetation composition in relation to hydrology will require information from three areas: 1) Riparian gradient position information for dominant species, 2) Surficial substrate correlations for dominant species, and 3) Data on expected changes in flood frequency, flow duration and channel substrate configuration resulting from changed hydrology. Our research protocol will provide the information necessary for 1 and 2, with the remainder of the required information being supplied by the Park Service in conjunction with parallel hydrologic and geomorphic studies.

For each of 6 hypothetical flow regimes, we will map hypothetical vegetation configuration within each study reach based on simulation of riparian gradient position. We will use a modified approach similar to the IFIM Flow Simulation model (Trihey and Wagner 1980) to relate flood frequency maps to expected vegetation zonation.

3.5 HISTORICAL VEGETATION ASSESSMENT

We will undertake a review of historical aerial photographs to ascertain trends in riparian vegetation extent and distribution within the study

segments. The distribution of vegetation in each segment will be mapped for each period for which photography is available: 1920s, 30s, 60s and for 1986. Understanding recent trends in vegetation within the study segments will aid interpretation of existing conditions and forecasting future changes expected under modified hydrology (cf. Connell and Sousa 1983).

4.0 Study Team Qualifications and Availability

4.0 STUDY TEAM QUALIFICATIONS AND ORGANIZATION

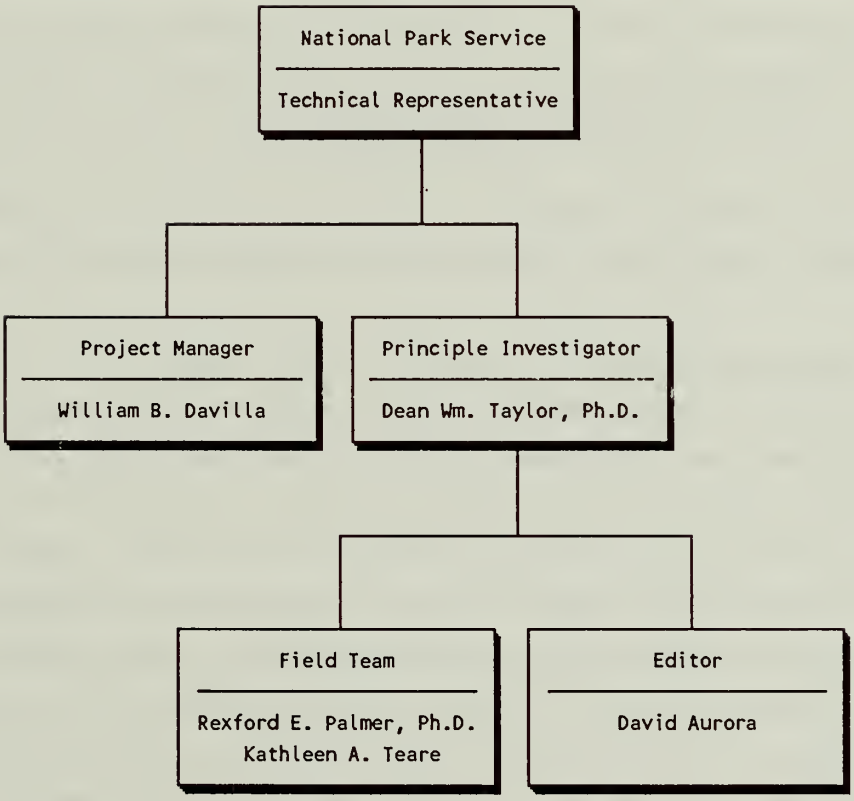
BioSystems has assembled a team of in-house experts on riparian ecology and vegetation analysis for stream systems throughout the western United States. The proposed study team offers a wide range of expertise and experience with the methods necessary to characterize riparian vegetation, identify riparian attributes sensitive to changes in hydrologic regimes, and model changes in riparian vegetation structure as a function of alterations in hydrologic conditions (both anthropogenic and natural). We have reviewed the RFP closely to determine the appropriate expertise, and the extent to which it is required, without incurring excessive costs.

As you will see by the following key personnel profiles, the BioSystems staff offered is highly experienced and qualified to respond to the issues and to develop a high quality and accurate study of stream courses identified in the RFP.

We believe the combination of our in-house expertise and extensive research experience on the ecological effects of streamflow modification on riparian vegetation makes our proposal best qualified to provide the services requested in a cost effective and timely manner. All personnel in key tasks and activities are available to begin work as early as 1 October 1988 and will maintain their proposed commitments through the completion of the project.

The proposed study team organization is shown in Figure 4.1. The following profiles provide *summary* information on their qualifications, education, experience relevant to this study, and their proposed role in the study. For more details on the entire study team, please refer to the resumes provided in Section 9 of this proposal.

Figure 4.1. Study Team Organization



DEAN Wm. TAYLOR, Ph.D., PRINCIPLE INVESTIGATOR

Dr. Taylor, BioSystems senior botanist, would serve as Principal Investigator under the proposed contract. He is a plant ecologist with recognized experience in riparian ecology.

Expert Testimony - Dr. Taylor has served as an expert witness before both judicial and administrative proceedings relating to riparian and water rights determinations. He served as expert witness for the Bureau of Land Management in United States vs. State of California (S-80-696, E.D., Cal.). In this precedent-setting case, ownership of relicted riparian lands about Mono Lake in the Mono Basin National Scenic Area was adjudicated. The court found in favor of the United States - a judgement upheld by both the Appellate Court and U.S. Supreme Court. The case sets precedent in establishing for the first time that the doctrine of reliction and accretion applies to artificially dewatered terminal desertic lakes and their tributaries.

Dr. Taylor has offered expert testimony in water rights hearings before California State Water Resources Control Board. He was the principal expert on riparian vegetation dewatering effects along the lower American River Parkway in Sacramento, a unique and diverse riparian system in an otherwise urban setting. The Board was hearing evidence on a proposal by the East Bay Municipal Utilities District to divert 220,000 acre-feet of flow into the Folsom South Canal. Profound, and continuing, geomorphic and successional changes in this riparian corridor, as determined from historical photographs, were demonstrated to be the result of upstream dam construction. Dr. Taylor's data showed that the magnitude of vegetation impacts of the proposed diversion wound be masked by the overriding successional changes presently underway.

Riparian Research - Dr. Taylor has conducted extensive original research on the ecological effects of streamflow modification on riparian vegetation. He has served as the principal consultant to Pacific Gas & Electric Company in their riparian ecology research program in the Sierra Nevada. The results of these studies have been utilized by both Federal and State Agencies in their

regulation of instream-flow requirements for hydroelectric facility relicensing. His research on the ecological consequences of stream diversions in the watershed serving the Los Angeles aqueduct heightened the concern over riparian losses in arid cismontane California, and has led to a broader focus on this issue. Dr. Taylor spent three years with the group led by Prof. Jerry Franklin in Corvallis, Oregon. The Corvallis group conducted extensive research on land-water interactions in forested riparian ecosystems in conjunction with the Long-Term Ecological Research Program (NSF) and the Man and the BioSphere Program (UNESCO) at the H.J. Andrews Experimental Forest.

WILLIAM DAVILLA, PROJECT MANAGER

William Davilla is a principal and senior botanist with BioSystems. He received his M.A. in botany and plant ecology from San Jose State University. He has more than 15 years professional consulting experience, the last 10 with BioSystems. During this period he has conducted and managed over 100 professional plant and vegetation studies. He has designed, implemented, and supervised vegetation surveys, habitat characterizations, impact assessments and rare and endangered plant inventories throughout the western United States. Mr. Davilla has managed several riparian studies in California including those related to impact assessment of diversion. Mr. Davilla will provide project management and agency contact and will assist in other technical phases of the study.

REXFORD E. PALMER, Ph,D., FIELD INVESTIGATOR

Dr. Rexford Palmer is a plant taxonomist and plant ecologist with extensive experience in the western United States. He received his doctorate in botany from the University of California at Davis. During his tenure there he taught courses in plant taxonomy and plant ecology. He was principal investigator and manager for the riparian vegetation studies on the Clavey and Tuolumne Rivers in California. These studies included vegetation

description, mapping, and quantitative sampling of riparian communities. Mr. Palmer has conducted over 20 professional rare plant surveys and a habitat studies throughout the western states and is highly knowledgeable of the floras in this region. His participation in the field studies and his familiarity with the proposed methodology will assure an accurate and defendable project.

KATHLEEN A. TEARE, FIELD TECHNICIAN

Kathleen Teare is a field botanist with BioSystems. She studied botany at the University of California at Davis. She has over ten seasons of field experience in plant ecology studies as a biological technician. She has conducted and assisted in vegetation studies including rare and endangered plant surveys, forest inventories, vegetation management, habitat characterization, and habitat mapping throughout California and Alaska. Ms. Teare worked for the National Park Service and the U.S. Forest Service for eight seasons and therefore is familiar with the structure and function of these federal agencies.

5.0 Performance in Similar Studies

5.0 PERFORMANCE ON SIMILAR STUDIES

This section describes BioSystems' experience with research projects and similar studies that qualify us for these and other aspects. Through the following project profiles we demonstrate our Company's ability to conduct modeling studies, large-scale, multi-year ecological investigations, and studies with strict deadlines. We also profile BioSystems studies that emphasize our abilities to conduct large-scale field investigations requiring equipment and support services to safely and efficiently perform the required studies.

A detailed Statement of Qualifications for BioSystems Analysis, Inc. is appended to this proposal (Appendix C). In this document are profiles of all projects completed since or inception in 1978. For additional job profiles performed by our study team members, please refer to the individual resumes of our personnel for this project (Section 10.0).

5.1 RIPARIAN VEGETATION STUDIES

Title: **Empirical Modeling of Ecological Effects of Stream Diversions, Sierra Nevada**

Client: Pacific Gas and Electric Company
Budget: $50,000 cost reimbursable
Duration: 2 years

BioSystems botanists established standardized sampling protocols for studies of riparian vegetation under PGandE's Riparian Ecology Project. Data collected from several different PGandE studies were combined. The data set, representing the single largest body of data on California riparian vegetation, will be utilized for empirical verification of simulation models under development by PGandE.

Title: **Demographic Characteristics of Dominant California Riparian Plants**

Client: Pacific Gas and Electric Company
Budget: $35,000 cost reimbursable
Duration: 2 years

BioSystems' botanists conducted ecological research on the life-history attributes of dominant trees and shrubs on selected montane streams on both the western and eastern slopes of the Sierra Nevada. Demographic and population data was collected on density-dependent recruitment and sapling survival. Destructive sampling of characteristic riparian shrubs and increment coring of characteristic riparian trees were methods used to determine the relationship between size, age, and biomass for riparian species on both sides of the Sierra Nevada. Seedling mortality was measured and tracked for the development of lifetables and to estimate age-dependent mortality rates.

Regression equations were developed to predict stem age, biomass and leaf area from stem basal diameter and/or stem length. Life-tables were prepared for all species studied along with age class distributions by site. A subsequent demographic data base was assembled for use in the development of a riparian vegetation model for both the east and west sides of the Sierra.

Title: **Structure of riparian plant communities, lower North Fork Kings River, Sierra Nevada, California**

Client: Pacific Gas and Electric Company
Budget: $68,000 cost reimbursable
Duration: 1 year

Riparian vegetation along an 19 km diverted reach of the lower North Fork Kings River was studied. Data on vegetation composition was obtained using plotless (releve) methods at 77 sites. Data on vegetation structure and zonation within the riparian zone was obtained on 129 transects at 12 sites. Comparison of vegetation composition above and below points of diversion and major tributaries were made using both univariate and multivariate

methods. This information combined with hydrologic modeling demonstrated levels of impact to riparian vegetation under alternate Project configurations.

Title: **Evaluation of the Use of the Releve Technique for the Characterization of Stream Diversion Effects on Riparian Vegetation**

Client: Pacific Gas and Electric Company
Budget: $27,000 cost reimbursable
Duration: 2 years

BioSystems' botanists conducted extensive, reconnaissance-level vegetation sampling with the upper San Joaquin River watershed in the central Sierra Nevada of California. The research program was designed to test the effectiveness of using reconnaissance-level (releve) vegetation sampling techniques as a rapid, initial method for assessing the ecological effects of streamflow modifications on riparian habitat and to help control for preexisting vegetation differences at sites of streamflow modification by providing a large, cost-effective data base. This technique provided a method for collecting data at a level appropriate for identifying major natural patterns of variation in vegetation at a landscape or watershed scale. The large data base provided a means for attributing differences observed or measured in riparian vegetation attributes above and below streamflow diversion sites to treatment effects rather than those attributable to natural variation in riparian vegetation within the watershed.

Title: **Riparian Vegetation Studies for the PGandE Crane Valley Hydroelectric Project (FERC 1354)**

Client: Pacific Gas and Electric Company
Budget: $40,000 cost reimbursable
Duration: 2 years

BioSystems conducted ecological studies designed to evaluate the effects of streamflow modification on riparian vegetation within the Bass Lake watershed on the west slope of the Sierra Nevada. A two-staged vegetation sampling approach was utilized to study diversion effects. The first stage consisted of extensive, reconnaissance level vegetation samples (389 releves) that characterized environmental gradients and responses between riparian

sites. The second stage involved a detailed, intensive (transect based, 130 in number) vegetation sampling that characterized environmental gradients and plant species responses within riparian sites. The results of this study included the recognition of 9 major vegetation types (series) and 29 riparian community types and the ability to attribute differences in riparian vegetation above and below diversion sites to diversion effects and not natural variation.

Title: **Potential Ecological Effects of Reduced Instreamflow on Riparian Vegetation along the Lower American River, Sacramento, California**

Client: East Bay Municipal Utility District
Budget: $35,000 cost reimbursable
Duration: 2 years

BioSystems' botanist assessed the potential impacts of water diversion on riparian vegetation along a 21 mile stretch of the lower American River, from the Folsom/Nimbus dam complex to the confluence with the Sacramento River, California. To predict the possible consequences of additional water diversion from the upstream end of the Lower American River, studies were done that characterized and profiled existing riparian vegetation along six reaches of the river. These profiles were used to correlate vegetation position, composition and structure with past and present channel geomorphology and hydrology. These findings were utilized to predict possible future changes to riparian vegetation that may be directly caused by changes in baseline flows rather than the river's natural regime.

The findings of this study were presented as testimony to the California State Water Resources Control Board.

Title: **Evaluation of Wildlife Mitigation at Chief Joseph Dam**

Client: U.S. Army Corps of Engineers, Seattle District
Budget: $15,000 firm fixed price
Duration: 1 year

Modification to Chief Joseph Dam on the upper Columbia River in Washington, resulting in a 10-foot pool rise and reservoir level fluctuations were the subject of a Design Memorandum specifying agree mitigation. BioSystems designed a monitoring plan to evaluate the effectiveness of mitigation for riparian vegetation and wildlife including threatened and endangered species at the site. Monitoring encompassed both direct measures of mitigation success (revegetation survival, riparian succession, raptor poles, artificial nests) and its effect on local wildlife populations.

5.2 OTHER RIPARIAN STUDIES

Title: **Chinook Salmon Biophysical-Economic Model for the Sacramento River Basin**

Client: NOAA-National Marine Fisheries Service
Budget: $204,000
Duration: 3 years

BioSystems scientists developed a flow-based population model to estimate the economic value of in-river flows to the chinook salmon fishery. The study evaluated the effect of specific out-of-basin diversion on in-river fisheries. Model development required thorough research on chinook salmon life history, production, instream flow requirements and habitat conditions, and the relationships between basin hydrology, water management and productivity of chinook salmon in the Sacramento Basin. BioSystems developed a biophysical model to simulate production of salmon under different flow scenarios and provide input to an economic model developed by Meyer Resources, Inc., a major subcontractor under BioSystems direction.

Title: **Development of Stream Corridor Inventory and Evaluation System (SCIES)**

Client: U.S. Fish and Wildlife Service
Budget: $75,000 firm fixed price
Duration: 1.5 years

BioSystems developed a methodology for assessing the value of stream and riparian areas to fish and wildlife. The methodology is micro-computer based and can be used to identify and rank high-value areas or stream reaches. It can support inventories of riparian ecosystems on basin-wide scales, model impacts, and compare management options.

BioSystems reviewed existing inventory methods and structured SCIES to allow fish and wildlife managers to incorporate the results of IFIM, HEP, and HSI information and to build on existing classification systems in determining value. SCIES was designed to provide fish and wildlife managers with a flexible, cost-effective, and comprehensive tool that could adjust to specific project conditions and objectives, but still yield information comparable across geographic regions. BioSystems has since been asked to present SCIES at numerous professional societies and conferences.

Title: **Energy-Related Use Conflicts for the Columbia River Estuary**

Client: U.S. Fish and Wildlife Service
Budget: $97,000 firm fixed price
Duration: 2 years

This report provides a comprehensive reference work for fish and wildlife managers confronting energy development in the Columbia River estuary. It required an integration of biological and ecological data at all levels of organization from species to ecosystem, together with pragmatic evaluation of utility programs and industrial trends and with detailed assessment of energy-related technologies.

The study projects energy-related developments in the estuary over a 25-year period; summarizes development impacts upon fish and wildlife in estuarine systems; models developments in six estuarine ecosystems; provides

detailed accounts of estuarine species of concern; logs site-specific conflicts by river mile; summarizes cumulative impacts; defines planning, policy, and regulatory processes governing development; and characterizes management and mitigation practices for specific species and generic types of energy facilities. An accompanying atlas maps all information at 1:250,000.

Title: **Entrainment Studies on the Eastern Slope of the Sierra Nevada, California**

Client: Southern California Edison Company
Budget: $85,000 cost reimbursable
Duration: 1 year

BioSystems is conducting studies at three power plants and intake structures on eastern Sierran slope streams (Bishop and Lundy Creeks) to assess the rate and significance of power plant entrainment on resident rainbow and brown trout populations.

Title: **DeSabla-Butte Creek Temperature Modeling Study**

Client: Pacific Gas and Electric Company
Budget: $104,000
Duration: 2.5 years

BioSystems evaluated PGandE's method of temperature control in a reach of Butte Creek near Chico, California. PGandE controlled temperature by releasing flows from a diversion dam to protect a population of chinook salmon that summer in the creek; this flow would otherwise be used for power production. Temperature monitoring and modeling studies were used to evaluate current practices and to develop an operating plan to maximize power production while minimizing thermal stress on the fish.

Title: Environmental Costs and Benefits of Hydropower Development in the Pacific Northwest

Client: Bonneville Power Administration
Budget: $80,000
Duration: 2 years

In this ground-breaking economic analysis, BioSystems developed a method for estimating a regional environmental cost function for hydroelectric development and used it to estimate costs for hydro impacts on fish, fishing, hunting, riparian habitat, and free-flowing streams. Staff scientists identified and quantified environmental resources significantly at risk from hydro development in the Pacific Northwest; analyzed and categorized the kinds of development associated with the full range of regional hydro development, from small run-of-the-river to large dams; and developed indices to relate the impacts of various hydro project elements to regional resources. BioSystems also assisted in BPA's public involvement and review process.

Title: Analysis of Environmental Costs and Benefits: A Case Study of the Sultan Hydropower Facility

Client: Bonneville Power Administration
Budget: $79,000
Duration: 1 year

This case study of the costs of hydroelectric environmental impacts was one of a series commissioned by BPA. BioSystems economists and ecologists worked together to develop and test economic methodologies for impact costing. This required reviewing the impacts of the dam, selecting significant impacts for costing, defining linkages between impacts and economic values, developing or adapting methods to measure environmental costs in economic terms, and quantifying levelized dollar costs. Existing data were used to value recreation, wildlife productivity, black-tailed deer, furbearers, commercial timber, and human health impacts from operating the dam. Original data were gathered to cost impacts on whitewater kayaking and old-growth forests.

Title: Big Creek Expansion Project Generation Sites, IFIM and Fisheries Studies (BICEP)

Client: Southern California Edison Company
Budget: $750,000 cost reimbursable
Duration: 2.5 years

BioSystems assessed the impact of proposed changes in operations and new hydroelectric facilities on cold- and warmwater fish species in seven tailwater reaches on the San Joaquin River and tributary Sierran streams. Field surveys provided baseline data on Project operations and mitigation opportunities. This project resulted in a three-volume riverine fisheries technical report, a reservoir fishery report covering seven lakes, and a technical report on Shaver Lake limnology, hydrology, and fisheries. The studies supported amendments to four FERC Exhibit E's.

Specific studies included hydrologic and temperature modeling of the effects of spills and thermal stress on fish population structure, abundance, and distribution; habitat mapping of instream and riparian areas; IFIM assessment; temperature modeling; fish abundance, habitat use, community composition, and limiting factors or life stages; and a creel survey at Shaver Lake. BioSystems' own SCIES methodology was used to assess the value of stream reaches to target fish species and lifestages under varying instream flows. The SCIES application combines the IFIM, temperature model, and fish population data to tank the relative quality of stream resources under different management policies. Detailed analyses of habitat enhancement potential were provided for the stream reaches and reservoirs.

5.3 LARGE-SCALE, MULTI-YEAR, INTERDISCIPLINARY STUDIES

Title: **Ecology of Bald Eagles in Central Arizona**

Client: D.O.I., Bureau of Reclamation
Budget: $1,400,000
Duration: 4 years

BioSystems is conducting a $1.4 million, four-year study in central Arizona on bald eagles and their prey resource. This project is an in-depth ecological investigation of this endangered species in relation to proposed and existing water projects in Arizona. Raptor biologists are examining the relationship of bald eagle ecology to the Central Arizona Project. The study involves intensive field observation to determine home range; telemetry on juvenile and adult eagles; and studies on reproductive success, foraging and feeding behavior, habitat use, and migration.

Extensive reservoir and riverine fisheries studies are being conducted to determine the effects of water projects on fish, the eagle's primary prey resource. Tasks include mapping aquatic habitats and spawning areas in reservoirs, rivers, and streams; determining the relative importance of spawning in tributaries to lake and river fish populations; assessing changes in the total area of the littoral zone and the resulting effect of fish populations; water quality studies; determining sources of carrion; studying the seasonal distribution of reservoir and river fishes; and quantitative surveys of fish spawning chronology using snorkeling, scuba, and hydroacoustic gear. Existing IFIM data will be used, and additional data is being obtained by gill netting, seining and electroshocking.

Title: **Crane Valley Hydroelectric Project**

Client: Pacific Gas and Electric Company
Budget: $1,200,000 cost reimbursable
Duration: 2 years

BioSystems conducted a multidisciplinary baseline study and preparation of the biological, water quality, and geological portions of an Exhibit E for the relicensing of PGandE's Crane Valley Hydroelectric Project. Potential

impacts were determined and evaluated, and mitigation recommendations were prepared. This three-year, $1+ million project entailed twenty major research tasks, eleven technical reports, and resulted in eight technical reports and accompanying mitigation reports, as well as the Exhibit E for the Federal Energy Regulatory Commission.

The Crane Valley Project is comprised of a complex of hydroelectric facilities located in the California Sierra. Facilities included a major dam and four smaller diversion dams, a major storage reservoir, two smaller seasonal storage reservoirs and afterbays, three forebays, 14 miles of conduits, and over 20 miles of stream and 30 miles of transmission facilities.

BioSystems managed all research on fish, wildlife, botanical resources, water quality, and hydrology. Studies conducted by BioSystems included benthic invertebrate sampling; the effects of lake level fluctuations on reservoir fisheries; hydrologic data analysis for 35 gaging stations; vegetation habitat mapping; rare plant and rare wildlife field surveys, including field surveys for a rare riparian plant and statistical analysis of its ecological requirements; relevé and transect surveys of riparian vegetation and statistical analysis of relationships between streamflow and vegetation structure and composition; characterization of riparian wildlife, raptors, and other sensitive wildlife; and a full-year study of mule deer movement patterns and mortality along PGandE's water conveyances (canals).

Sampling and analysis of sediment transport in Project watercourses, water quality, and extensive field analysis of fish habitat, coupled with IFIM assessments and temperature modeling were also conducted by major subcontractors under BioSystems management. Both anadromous and warmwater fish were studied, using IFIM and electroshocking.

Title: **Pit River Bald Eagle Study**

Client: Pacific Gas and Electric Company
Budget: $750,000 cost reimbursable
Duration: 3 years

BioSystems was prime contractor for this $750,000, three-year ecological investigation of a population of endangered bald eagles and their prey resources in Northern California. The study's objective was to determine the effects of flow changes proposed as part of PGandE's relicensing application to FERC for the Pit-3,4,5 hydroelectric project. The Project is located in an area supporting the greatest nesting density of bald eagles in Northern California and potentially affected several resident fish species that were the eagle's primary prey resource.

BioSystems managed a detailed investigation of fish prey populations by the University of California at Davis Fisheries Group, and conducted two years of field investigations to monitor eagle wintering and breeding activities. BioSystems biologists radio-telemetered bald eagles and followed them as far as British Columbia. They also radio-telemetered Sacramento sucker populations in the Pit River; characterized human disturbance and public-use factors affecting the eagles; evaluated four management approaches proposed by state and federal agencies for an interagency Pit River Bald Eagle Management Plan; and integrated the results of several major concurrent studies, including IFIM, water quality, water temperature, habitat modeling, and algae studies. The resulting report is the most comprehensive research report on the species published to date.

Title: **MX Missile Base Biological Assessment**

Client: U.S. Air Force, via EDAW)
Budget: $600,000 cost reimbursable
Duration: 1 year

BioSystems conducted extensive baseline surveys and provided biological constraint information to the MX Operational Base interdisciplinary planning team. Field teams assessed the impacts associated with proposed facilities at five sites in New Mexico, Nevada, and Utah. BioSystems also developed the

biological portions of a comprehensive resource management plan aimed at reducing conflicts and preserving natural resources.

Studies included literature reviews; terrestrial vertebrate baseline studies; soils classification; plant community characterization and mapping; abundance and distribution of small mammals, lagomorphs, large mammals, herptofauna, and avifauna; and 22 integrated biological community definitions at the five sites. Unique communities, habitats, and special features were treated in depth. Specific studies and briefs were prepared on species of concern, including desert tortoise, desert bighorn sheep, mule deer, Rocky Mountain elk, feral horses and burros, pronghorn antelope, black-footed ferret, bobcat, kit fox, mountain lion, Utah prairie dog, spotted bat, gila monster, lesser sandhill crane, lesser prairie chicken, sage grouse, and six species of raptors.

Title: **Skagit River Bald Eagle Study**

Client: Seattle City Light (City of Seattle, WA)
Budget: $300,000 cost reimbursable
Duration: 2 years

The Skagit River of Washington supports one of the largest concentrations of wintering bald eagles in the United States. Impacts on wintering eagles from the proposed Copper Creek Dam were defined in this study and mitigation measures developed. Two winters of research were conducted on the eagle population and its salmonid food resource base. Staff scientists censused eagle occurrence and distribution in relation to the availability of salmon carcasses; characterized eagle habitat requirements in relation to existing and future conditions, including human disturbance factors; and used radio telemetry to analyze eagle movement patterns, both locally and during their migration to the breeding grounds.

BioSystems managers worked at every level, directing field research and all phases of public involvement, administering five research contracts, and conducting Section 7 consultation with the U.S. Fish and Wildlife Service, as well as separate consultations with the National Park Service (North Cascades National Recreation Area) and U.S. Forest Service (Wild and Scenic Rivers). Ancillary contracts included a documentary film and a pioneering

effort to determine eagle food distribution through implanting telemetric equipment in over 100 post-spawning salmon.

Title: **Fossil 1 and 2 Transmission Corridor Study**

Client: Pacific Gas and Electric Company
Budget: $400,000 cost reimbursable
Duration: 2.5 years

This four-volume study and atlas present the results of aerial and ground surveys conducted over approximately 800 linear miles of proposed transmission corridors for 500-kV powerlines associated with PGandE's Fossil 1 and 2 project. The report discusses biological constraints to routing based on potential powerline-waterbird interactions; maps of waterbird habitats, intensity of use, and wetlands; multiple surveys of waterbirds conducted throughout the winter; and on a waterbird conflict sensitivity analysis. Appropriate mitigation procedures were developed from a literature survey. The atlas consisted of 15 minute habitat and special feature maps.

Title **Fossil 1 and 2 Power Plant Siting Studies**
Client: Pacific Gas and Electric Company
Budget: $350,000
Duration: 3 years

BioSystems completed a major biological baseline and siting study for four proposed power plant sites in California's Central Valley. BioSystems scientists collected and compiled data, assessed impacts, and prepared the biological portions of PGandE's Application for Certification (AFC), and testified during the Notice of Intention (NOI) proceedings.

Field studies involved small mammal capture-recapture using live trapping and snap trapping; preparation of voucher specimens; Emlen bird transects and Shannon-Weaver diversity indices in all habitats; raptor nesting surveys and owl calling; documentation of seasonal changes in species occurrence and abundance in all habitats; carnivore scent stations and tracking; lagomorph flush-counts; year-round roadside raptor censuses to determine relative abundance and habitat utilization; quantitative botanical studies (relevé

analyses, line transects, and habitat characterization); aquatic sampling by electroshocking, seining, and gill netting; plant species collections and preparation of herbarium voucher specimens; and rare and endangered species studies for more than 20 plants, 2 mammals, 5 birds, 2 fish, and one insect.

Title: **Fish and Wildlife Resources of the Coastal Aqueduct, Santa Barbara Extension and Lompoc Extension Routes**

Client: California State Department of Water Resources
Budget: $300,000 cost reimbursable
Duration: 2 years

BioSystems is conducting studies of the sensitive fish and wildlife resources along the State Water Project Coastal Aqueduct route. This project is planned to consist of a 83 mile long, 60 inch diameter, pipeline running from northwestern Kern County through San Luis Obispo and Santa Barbara counties. BioSystems is conducting similar studies along the proposed Lompoc Extension pipeline running from Lake Cachuma in Santa Barbara County and connecting to the terminus of the Coastal Aqueduct.

Preliminary studies of the sensitive fish and wildlife resources have been completed within the initial one mile wide study corridor. Resources were inventoried using a custom designed dBase III+ system for linear survey data analysis. Sensitive resources were mapped on topo quad overlays for use during selection of the aqueduct final alignment. Detailed studies will be undertaken in the a 350 ft. wide study area after selection of the pipeline final alignment.

6.0 Facilities and Equipment

6.0 FACILITIES AND EQUIPMENT

BioSystems Analysis is a full-service environmental consulting firm with approximately 40 employees in five offices. Since our inception in 1978, we have strived to continually refine our data and word processing capabilities, our report production such as graphics and editing, and our contract administration procedures.

In our 2000 square foot Santa Cruz offices managed by Carl Thelander, we have a full line of computer facilities and word processors, a full graphics staff with the abilities to do any anticipated graphics/mapping needs, typesetting, and camera work. A similar facility exists at our Sausalito (California) office managed by Mr. John Garcia. We have Hayes Smartcom modems and Ricoh FAX machines to provide rapid communications between BioSystems Analysis and client offices. In-house each office has full copying facilities to produce any number of high quality documents on short notice.

BioSystems Analysis has a division headquartered in Portland (Oregon), BioTech Communications, which is a technical editing and writing service. In addition to their expertise, each office has qualified technical editors to assist in document production. For example, BioSystems Analysis recently prepared a hardbound book for The Peregrine Fund, Inc. entitled, *Peregrine Populations: Their Management and Recovery*, which is a 1,000 page compilation of papers presented at the 1985 Raptor Research Foundation meetings in Sacramento (California).

Data support facilities focus on Lotus 1-2-3 and dBASE III. For most statistical applications we utilize the SYSTAT software program, an IBM-PC oriented version of SAS. All BioSystems Analysis project managers use these systems.

For our corporate accounting and job cost data, we use Deltek. This is managed by a full-time accountant working closely with our CPA. Our banking is done through Commercial Bank of San Francisco where we

maintain a $200,000 line of credit, which enables us to meet the monthly cash flow requirements of most large projects.

We are please to offer the services of BioSystems Analysis, Inc. We feel that this study will be best served by a firm with a long, strong track-record of conducting studies of this nature, and with the financial stability to carry out a three-year project. These features complement our strong biological, statistical, and modeling expertise to provide an efficient and cost effective study.

For more details, please refer to Section 10.0, Statement of Qualifications.

7.0 Project Management

7.0 PROJECT MANAGEMENT

7.1 PROGRESS TRACKING AND REPORTING

Communication is critical to progress tracking and project control. Efficient handling of draft and final document production and professional editing will be an important element of performance on this contract.

Telephone Reports. BioSystems Project Manager (Davilla) and Principal Investigator (Taylor) will maintain regular telephone contact with NPS managers, keeping them informed on developments. Important issues which may be brought up in bi-monthly progress reports (e.g., technical problems, redefinition of work scope) will be initially raised in these telephone contacts.

Bi-Monthly Progress Reports. BioSystems views progress reports as an essential aspect of communication with clients. We normally prepare these in letter form, no more than three pages for submission to our contract manager. The bulk of each report summarizes progress during the preceding two week period; however, a look-ahead to the next period will also be included. Bi-monthly progress reports contain the following:

- Status of work accomplished versus that scheduled, including an explanation of any schedule variance and plans for recovering slippage.
- Actual utilization of manpower and funds, compared with planned effort and expenditure, including an explanation of cost variance and discussion of any changes in project funding requirements.
- Summary of technical performance, including a highlight of any potential or real research problems and proposed solutions.
- Identification of report status, including formats, outlines, in-house reviews, and confirmation of delivery to NPS for review.
- Summary of meetings and other contacts with NPS and agency personnel.

- Confirmation of any adjustments in scope or effort authorized by NPS.
- Tasks projected to be completed or initiated in the upcoming period, and objectives for the month.

Progress reports are prepared by the BioSystems Project Manager in conjunction with the Principal Investigator. They are based on in-house reports submitted by our research staff. Managers meet informally with their research groups to discuss issues, confirm progress, and review problems. These in-house progress meetings are used to review progress in all areas of performance.

BioSystems recommends a progress meeting (at the end of the data collection phase) to resolve technical issues which arise in the course of our investigations. If these problems require NPS attention (e.g., affect schedule or cost, change technical approach) the Project Manager will notify the NPS Contract Manager immediately by telephone and follow up with a brief letter documenting and explaining the concern. If the Contract Manager and Project Manager find a special meeting necessary, they may arrange it based on this communication. These meetings would involve the BioSystems Project Manager and appropriate professional staff, the NPS Contract Manager and other technical advisors as needed. Similar special meetings may be arranged if project management issues requiring resolution arise.

Editing. All deliverable reports and documentation for models will, of course, follow any formats defined or requested by NPS.

We normally prepare technical reports in ordinary scientific format and style, using the latest edition of the Council of Biology Editors Style Manual. A draft outline is submitted for approval to the NPS Contract Manager as early as practical—in any case before substantial work begins on the report. We recommend that major reports contain an abstract describing the objectives of the study and highlighting results; a Report Summary, suitable for extraction and separate circulation to lay, professional, and executive audiences; an introduction stating objectives and background; a discussion of

study methodology; a full presentation and analysis of data; and documented conclusions and recommendations.

BioSystems' objective is to produce concise, well-written, and well-organized reports and documents. Particular attention is paid to logic, flow, and style in editing, minimizing NPS burden for document control. Our editorial control assures that a single, scientific style characterizes the document. Scientific rigor, clarity, and usefulness are assured by the proper balance of text and illustration. When needed, highly technical terms are defined in the text or in a glossary; otherwise such terms and other jargon are avoided. Our draft reports are suitable for technical review and distribution within NPS; finals include polished copy and camera-ready graphics.

Graphics. Clear summary graphics are vital when many interacting, complex factors, such as those in models, must be presented. Rendering quantities of data meaningful to decision-makers and the public requires condensation and formatting to highlight key trends or areas, emphasize significant differences, and facilitate comprehension. BioSystems understands information presentation problems and works closely with clients to design graphics tailored to their audiences. Our graphics resources include complete studios and trained artists at each of our offices; an eight-pen color plotter capable of interfacing directly with our microcomputers and graphic software; and a Stereo Zoom Transfer Scope for accurate reconciliation of basemaps, overlays, or aerial photos.

7.2 COST MANAGEMENT

BioSystems operates its entire accounting systems through a commercial software package called Deltek Government Contractor's Accounting and Management System. It is specifically designed for cost control and it provides true job costing and revenue recognition on a monthly basis. It covers from basic accounting and record keeping at the timesheet data entry level all the way through job status, billing, and production of balance sheet and income statements. The system ensures that Government audit

requirements are met. For a company of our size we feel it adds a great deal of credibility and accountability in the area of accurately managing the financial aspects of any contract we might encounter.

7.3 SCHEDULE

We have prepared a preliminary schedule by task for the proposed study. Modification of the due dates of deliverables will be subject to uncertainties related to court proceedings concerning the basin-wide water rights ajudication.

TASK	DATE
1. Reconnaissnace Orientation	26-30 September 1988
2. Data Collection	30 September-7 October 1988
3. Data Analysis	8 October to 31 October 1988
4. Preliminary Report Submittal	1 December 1988
5. Final Report and Map Submittal	30 March 1989
6. Testimony	as needed

We would begin work on the study immadiately upon award of contract. Given the strict scheduling requirements required of this study, we anticipate conducting vegetation sampling immidately after meeting with the NPS representative in late-September. The Principal Investigator would meet particiapte in the Reconnaissance Orientation. Field assistants would begin data collection immadately afterwards. Given the level of effort described in

the RFP, we expect that 8 field days would be requred to collect the required data (our field experience indicates that a 3 person crew is capable of sampling 10 transects per day, when transect length does not exceed 200 meters).

8.0 Literature Cited

8.0 LITERATURE CITED

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9.0 Resumes

WILLIAM B. DAVILLA
Principal

Education

M.A.	Botany	1980	San Jose State University
B.A.	Biology/Environmental Sciences	1971	San Jose State University

Employment History

1978-present	BioSystems Analysis, Inc.	Senior Botanist
1977-1978	Ryckman/Edgerley/Tomlinson & Associates	Terrestrial Ecologist
1975-1977	San Jose State University	Lecturer in Biology
1975-1977	Independent Consultant	Plant Ecologist
1972-1974	San Jose State University	Teaching Assistant
1971-1975	San Jose State University	Research Ecologist
	Sierra Club National Outings Committee	

Selected Experience

California Cal Project Application for Certification - Manager and field team supervisor of botanical studies, including rare plant survey, for a proposed Southern California Edison coal-fired electric generating facility in the Mojave Desert. Conducted detailed vegetation sampling methodology to characterize vegetation types of the project area, including power plant site, proposed pipeline, railroad access corridor, and transmission line corridor. Wrote vegetation section of AFC biological report.

Sacramento Municipal Utility District (SMUD) Geothermal Power Plant Application for Certification - Managed and directed botanical portions of the AFC studies for SMUD's Geothermal No. 1 power plant in Sonoma County. Conducted vegetation mapping within a one-mile radius of the site and performed the rare plant survey. Responsible for the preparation of vegetation sections of the AFC biological report and development of both mitigation and monitoring plans for both the power plant site and transmission corridor.

SMUD Geothermal No. 1 Revegetation - Project manager responsible for the design and implementation of a revegetation and monitoring program at the SMUD Geothermal No. 1 power plant in Sonoma County for SMUD and Stone and Webster Engineers. Tasks included collection, propagation, and planting of native adapted seed stock and the design and supervision of a hydroseeding erosion control program.

Diablo Nuclear Power Plant Early Warning Siren System Rare Plant Survey - Directed and conducted the rare plant survey of 50 proposed siren locations in San Luis Obispo County for PGandE. Supervised BSAI personnel in literature and herbarium survey for more than 20 species.

Homestake Mine Rare Plant Survey - Principal investigator and project manager of an intensive rare plant survey for the Homestake McLaughlin Gold Project in Lake, Napa, and Yolo counties for D'Appolonia Engineers. Directed and supervised field surveys over more than 20,000 acres, including more than 10,000 acres of serpentine habitats, resulting in the documentation of over 400 new rare plant occurrences. Occurrences were mapped and characterized, and probable project-related impacts were identified.

Pacific Gas and Electric Company Geysers Unit 21 Application for Certification- Project manager of terrestrial biological AFC studies for a proposed geothermal power plant and associated development in Lake and Sonoma counties. Directed and supervised field studies including vegetation mapping and habitat characterization, rare plant survey, sensitive wildlife survey, and implementation of the U.S. Forest Service Wildlife Habitat Relationships Program to evaluate the presence of habitat for sensitive wildlife. Responsible for preparation of reports, including impact analyses, and development of mitigation recommendations.

Pacific Gas and Electric Company Geysers Unit 22 Application for Certification- Project manager for upcoming terrestrial biological AFC studies for a proposed geothermal power plant in Lake County. Study scope and methodology are similar to those for Geysers Unit 21 AFC submissions.

Bowman-Spaulding Transmission Line Corridor Rare Plant Survey - Directed and conducted the rare plant survey of a 12-mile, 12 kV wood pole transmission line corridor in Nevada County for PGandE. Vegetation types were also characterized along the corridor. Responsible for preparation of final report.

Feather River Rare Plant Surveys - Conducted rare plant surveys for new license or relicense applications on several PGandE hydroelectric or related projects on the North and West Forks of the Feather River in Plumas County, including Yellow Creek, Rock Creek-Cresta, Jackass and Chambers Creek, Grisly-Maidu, Toad Town, and the 60 kV Grays Flat-Elizabethtown wood pole line. Responsible for preparation of final reports.

Rare Plant Survey for Texaco San Ardo Cogeneration Facility - Conducted rare plant survey for the proposed San Ardo cogeneration facility and support facilities in Monterey, Kings, and San Luis Obispo counties.

Humboldt Bay Power Plant Wetland Restoration/Mitigation - Designed and directed a wetland restoration/mitigation project for PGandE at their Humboldt Bay power plant. Supervised operation of field crews.

County Biologist, County of Santa Cruz - Conducted and prepared more than 10 biotic assessments for subdivision and residential developments in an on-going contract with the County of Santa Cruz Planning Department. Tasks include surveys for rare and endangered plants and wildlife, impact analysis, and development of mitigation recommendations.

Fossil 1 and 2 Powerplant Siting Studies - Developed all botanical data required for environmental assessments of four potential PG&E powerplant sites. Duties included one year of field research, rare and endangered plant survey, document preparation, impacts and mitigations.

Pacifica Master Plan - Identified and mapped coastal habitats within the City of Pacifica. Emphasis on critical habitats, locations of rare and endangered plants, and identification of coastal access points. Developed map of habitats and rare and endangered plant populations in coastal zone.

Salt Marsh Harvest Mouse and Wetland Studies on Montezuma Powerplant Site- Determination of vegetation composition and structure of Montezuma powerplant site wetlands. Defined and mapped extent and types of wetland habitats on-site. Described vegetation requirements of salt marsh harvest mouse.

Biotic Assessment of Alhambra Creek - Conducted biotic assessment of a seven mile segment of Alhambra Creek in Martinez, California for the U.S. Army Corps of Engineers. Emphasis on floristic composition of reaches and the potential occurrence of rare and endangered plant species. Characterized sensitive riparian and wetland habitats and the potential effects of streambed channelization.

Antioch Dunes Rehabilitation Project - Currently conducting a study involving the rehabilitation of a portion of the Antioch Dunes natural area for Pacific Gas and Electric Company. The Antioch Dunes natural area is the critical habitat of two federally protected vascular plants (Antioch evening primrose and Contra Costa wallflower) and one federally listed butterfly (Lange's metalmark). Population assessments were conducted on extant stands of rare and endangered plants and the host plant of Lange's metalmark. Supervised clean-up of area and propagation and replanting of the host plant of the butterfly.

Bonny Doon Ranch Biotic Assessment, County of Santa Cruz - Identified and mapped 12 habitats on the 521 acre ranch site. Emphasis was on locating and mapping the extent of three rare and endangered plants and six unique plant and animal species on-site. Duties included survey, document, and map preparation, impacts, and mitigations.

Soquel Creek, Santa Cruz County - Conducted a biological resource survey of Soquel Creek for the City of Capitola. Inventoried wildlife and vegetation along a one mile section of creek. Described and mapped the distribution of riparian and flood plan habitats.

Sierra Nevada Wilderness Impact Study, California - Conducted a five year study on the impact of human recreational activities on subalpine forest ecosystems of the Sierra Nevada for the Sierra Club National Outings Committee and the Yosemite National Park Service. Developed and conducted experiments necessary to characterize forest productivity and biomass, woodlitter regeneration, and firewood consumption in the wilderness area of the Sierra Nevada. Identified impacts and developed management procedures.

Salt Drift Studies, Pacific Gas and Electric Company - The state-of-the-art study on the effects of salts on vegetation contained in cooling tower drift was conducted. The study was performed in connection with the proposed Montezuma power plant. Previous studies had been performed using planted test plots. This study departed from previous efforts by utilizing in situ vegetation. A series of salt concentrations plus controls of water only was applied to the vegetation plots over the entire growing season. Samples were analyzed for surface salt and salts incorporated in the tissues and soils. Visual observations were recorded on leaf damage caused by salts.

Professional Affiliations

American Institute of Biological Science
Botanical Society of America
California Botanical Society
California Native Plant Society
Ecological Society of America

Publications and Reports

Davilla, W.B. 1972. Interim report on firewood use and availability in the Sierra Nevada. **In:** Interim status report Sierra Nevada Impact Study, H.T. Harvey et al. (eds.). Sierra Club National Outings Committee, San Francisco, CA.

Davilla, W.B. 1975. Status report for the inclusion on the Butano Ridge *Cupressus abramsiana* grove in the California Natural Areas Inventory. California Natural Areas Coordinating Council.

Davilla, W.B. 1979. Firewood production, use and availability in the high Sierra. **In:** Sierra Nevada Wilderness Impact Study, H.T. Harvey et al. (eds.). Sierra Club, San Francisco, CA.

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Taylor, D.W. and W.B. Davilla. 1986. A rare plant survey of Site 300, Lawrence Livermore National Laboratory San Joaquin County, California. Report to Science Applications International Corporation, Pleasanton, California. Prepared by BioSystems Analysis, Inc. 25 pp. + appendices.

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REXFORD E. PALMER Ph.D.

Botanist, Environmental Biologist

EDUCATION

Ph.D.	Botany	1982	University of California, Davis
M.S.	Botany	1976	University of California, Davis
B.A.	Botany	1971	California State University, San Jose

EMPLOYMENT HISTORY

1986-present	BioSystems Analysis, Inc.	Botanist
1984-1986	Holton Associates	Associate Botanist
1982-1984	Diablo Valley College	Instructor
1980-1982	University of California Davis	Post-doctoral Research Associate

REPRESENTATIVE EXPERIENCE

- U. S. Bureau of Land Management, Salem, Oregon. *Poa marcida* endangered species life-history and management studies.
- FERC Exhibit E, Ponderosa (Clavey-Wards Ferry) 400 MW Hydroelectric project. Project management, sensitive plant surveys, vegetation description and mapping, riparian vegetation studies.
- FERC Exhibit E, Garden Bar 75 MW hydroelectric power and water project, Sutter Irrigation District. Sensitive plant surveys and riparian vegetation studies.
- U. S. Bureau of Reclamation Kesterson Reservoir cleanup plan E.I.S. vegetation sampling, statistics, mapping, on behalf of Jones & Stokes, Inc.
- PG&E Collinsville proposed coal-fired power plant. Rare plant surveys and vegetation analysis.
- El Dorado National Forest, *Silene invisa* sensitive species studies.
- Instructor, Horticulture Department, Diablo Valley College, Pleasant Hill, California.

- Post-doctoral research associate, Botany Department, University of California, Davis.

PROFESSIONAL AFFILIATIONS

California Native Plant Society
California Horticultural Society
California Botanical Society
Botanical Society of America
American Society of Plant Taxonomists
American Society of Naturalists
Ecological Society of America

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Palmer, Rexford. (in prep). Cytology of artificial hybrids in *Holocarpha*.

Palmer, Rexford. (in prep). Evolutionary significance of heterocarpy in the Madiinae.

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Senior Plant Ecologist

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Present Position
Botanist, BioSystems Analysis, Inc., since 1984

Education
Ph.D. Botany, 1976, University of California, Davis
M.S. Botany, 1974, University of California, Davis
B.A. Biology, 1970, California State University, Fresno

Dissertation Title: Ecology of timberline vegetation at Carson Pass, Alpine County, California
Major Professor: Dr. Jack Major

Areas of Expertise
Flora and Vegetation, Plant Sciences

Honors and Awards
1970 Ralph McCoy Award, Biology Department, California State University, Fresno. Departmental Citation as outstanding graduate for 1970.

1972 Morley Wilderness Scholarship, Sierra Club

Employment History
1982-1984 Research Associate, Oregon State University, Department of Forest Science and Cooperator, U.S.D.A. Forestry Sciences Laboratory
1981-1982 Private Consulting
1980 Lecturer, Environmental Studies Board, University of California, Santa Cruz.
1978-1979 Ecologist, Mountain Research Station, Institute of Arctic and Alpine Research, University of Colorado, Boulder.
1977 Lecturer, Department of Biology, San Francisco State University.
1976 Postdoctoral Research Botanist, University of California, Davis.
1971-1976 Graduate Teaching Assistant to Associate In Botany, California, Davis.

Related Undergraduate (Seasonal) Employment
1966-1968 Naturalist, summer camp operated by City of Stockton at Silver Lake, Amador County, California.
1969 Seasonal Park Aid, California Division of Beaches and Parks, Sugar Pine Point State Park, Lake Tahoe, California.
1970 Seasonal Research Biologist, U.S. Department of the Interior, Sequoia-Kings Canyon National Park

Other Experience (Selected)
1972-1974 Board of Directors, California Native Plant Society
1972-1974 Rare Plant Committee, California Native Plant Society
1973 Chairman, California Botanical Society meetings.
1973-1986 Instructor, Yosemite Natural History Association, Yosemite National Park, CA.
1973-1979 Extension Instructor, University of California, Berkeley campuses).
1973-1978 Winter Ecology Instructor, Teton Science School, Jackson, WY.
1975-1985 Consulting Ecologist to U.S. Forest Service, Region 5 and Pacific Southwest Forest and Range Experiment Station Research Natural Areas Committee
1976 Conference on the Riparian Forests of the Sacramento Valley at Chico, CA. Invited Participant
1977-1982 Board of Editors, California Botanical Society for Madroño
1980 Program Chairman, Ecological Society of America, Western Section, annual meeting with the American Association for the Advancement of Science.
1984 Workshop on Instream Flow Requirements for Riparian Vegetation in the Sierra Nevada organized by Pacific Gas and Electric Company and the Southern California Edison Company. Invited participant.
1984-1985 Expert testimony for U.S. Department of Justice in: State of California vs United States, Civil No. S-80-696, U.S.D.C., E.D., Cal., ownership of relicted lands at Mono Lake, CA.

1984-1987 Riparian Technical Advisory Committee, Pacific Gas and Electric Company and the Southern California Edison Company.

1987 Large-flowered Fiddleneck Recovery Team, U.S. Fish and Wildlife Service.

Professional Organizations

American Association for the Advancement of Science
British Ecological Society
California Botanical Society
Ecological Society of America
International Association for Vegetation Science

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6. Taylor, D. W. 1976. Ecology of the timberline vegetation at Carson Pass, Alpine County, California. Ph.D. Dissertation, University of California, Davis. 269 pages. Dissertation Abstracts 38(1):48-B.
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23. Taylor, D. W. 1981. Plant Checklist for the Mono Basin, California. Contribution No. 3, Mono Basin Research Group.
24. Taylor, D. W. 1981. Endangerment status of Lupinus dedeckerae on the Inyo National Forest, California. U.S. Forest Service administrative report.
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52. Stone, R. D., G. L. Clifton, W. B. Davilla, J. C. Stebbins and D. W. Taylor. 1987. Endangerment status of the grass tribe Orcuttieae and Chamaesyce hooveri (Euphorbiaceae) in the Central Valley of California. pp. 239-247 in: T. Elias [Ed], Conservation and Management of Rare and

Endangered Plants. California Native Plant Society, Sacramento, CA. (20 percent)

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KATHLEEN ANN TEARE
Botanist

EDUCATION:

B.S. Renewable Natural Resources/Botany. 1979. University of California, Davis.

Forestry and statistics classes. 1984-85. Oregon State University, Corvallis, OR.

BIOLOGICAL EXPERIENCE:

Biological Technician, BioSystems Analysis, Inc., Santa Cruz, CA. 4/86-88

Arizona Eagle Ecology Study. Aerial radio telemetry of migrating juvenile bald eagles by small plane from Phoenix, AZ to Yellowstone Park, WY and Manitoba. 6-7/88

San Bruno Mountain, PG&E. Field work, status reports and maps for rare plant survey. 3-5/88

San Joaquin Valley and Elk Hills. Field studies for rare plants under transmission lines and in petroleum reserve. 2-5/88

Orcuttia rare plant report. Produced 230 maps illustrating population status and locations of seven rare plant species. 1987

Status Survey of Three Rare Plants Endemic to the San Joaquin Valley. Assisted with the field work, graphics and edited the report. 1986

PG&E. Conducted ground and aerial radio telemetry on bald eagles from Eagle Lake, CA to Vancouver Island, BC. Observed and recorded juvenile bald eagle behavior in the nest area. 8/86

Big Creek Expansion Project, SCE. Managed and produced appendices for seven reports including 100 topographic maps illustrating vegetation types and rare plant locations, vegetation descriptions, sensitive plant and animal species reports. Authored the vegetation and rare plant sections of the text and edited all 7 reports. 1986-87

Arizona Transmission Project. Assisted with floristic and vegetation field work along a transmission right-of-way in Nevada and Arizona. 4/86

General Administration. Document production, editing and word processing.

Biological Technician, Lake Clark National Park, AK. Managed and conducted a forest inventory for the subsistence house log program and authored the report. Used aerial radio telemetry to census caribou and Dall sheep. 5/85-10/85

Biological Technician, Wrangell/St. Elias National Park, AK. Initiated, administered and curated the herbarium including developing procedures, collecting and curating specimens. Inventoried all-terrain-vehicle trails and campsites, and co-authored the summary report. 4/84-10/84

Biological Technician, USDA Forestry Sciences Lab, Anchorage, AK. Crew leader responsible for sampling vegetation for a resource inventory survey in interior Alaska including vegetation typing using aerial photo interpretation. Helicopter foreman responsible for navigating to field plots and proper safety procedures. 5/83-9/83

Biological Technician, Inyo National Forest, CA. Conducted a sensitive plant survey. Sampled and analyzed wildlife habitats in timber compartments. 6/82-10/82

Forestry Technician, Yosemite National Park, CA. Monitored and mapped back-country lightning fires. Assisted in the management of prescribed burns of 3,000 acres. Established permanent vegetation plots in several burns, and measured fire intensity, preburn and postburn vegetation and fuel, and plant succession after fire. Located and mapped rare plants, monitored weather stations and participated in fire reconnaissance by helicopter. 6/80-11/80

Research Assistant on two USDA Forest Service Research Natural Area Ecological Studies in Shasta-Trinity National Forest, CA. Field work included releves, plant species lists and plot sampling of vegetation aggregations. 9/79

Herbarium Curator, University of Colorado, Mountain Research Station, CO. Collected, identified and curated plants of the Front Range for the Station and the University herbariums including boreal forest, meadow and alpine plant identification. 6/79-8/79

Herbarium Curator, USDA Cooperative Extension Service, College of the Virgin Islands, St. Thomas, VI. Initiated and curated the herbarium and supervised two aides. Collected, identified and curated specimens. Lectured to college classes. 9/78-3/79

Forestry Technician, Klamath National Forest, CA. Silviculture crewmember sampling forest vegetation for plantation survival, thinning and herbicide evaluations using fixed and variable radius plots, aerial photo interpretation and topographic maps. 6/77-9/77

Forestry Technician, contract with Klamath National Forest, CA. Determined the reforestation potential of unstocked lands through statistical survey of trees/acre by species, basal area/acre, site class, vegetation unit name, and soil analysis. 6/76-10/76

OUTDOOR RECREATION EXPERIENCE:

Visitor Information Specialist, Inyo National Forest. CA. Presented visitor information on wilderness areas, recreational facilities and activities, and regulations for Inyo National Forest, Mono Lake and Yosemite National Park. Issued wilderness and fire permits, and radio dispatched. 6/81-11/81

Visitor Information Specialist, Mono Lake Committee, Lee Vining, CA. Led natural history field trips and staffed the information center. Responsible for the book-keeping and accounting for the non-profit corporation. 10/79-6/80, 12/80-6/81

YCC Workleader, Eldorado National Forest, Jackson, CA. Supervisor of a coed crew of 10 Youth Conservation Corpsmembers. Work projects included reconstruction of a campground, constructing an exclosure fence, and building an outhouse in the wilderness. Instructed environmental education and lifeguarded. 6/78-8/78

Recreation Volunteer, Outdoor Adventures, UC Davis, CA. Instructor of field classes in crosscountry skiing and snow camping for 4 winters, and guide for white-water raft trips for 2 seasons. 10/74-6/78

Backpack Trip Leader, Coast Range Hike and Hut, Palo Alto, CA. Guide for 5-day hikes with 12 youths aged 12-18. Instructed natural history and outdoor living skills, coordinated camp chores and counselled trip members. 6/75-8/75

CERTIFICATIONS:

Student Pilot, 1986-1988
Helicopter Management Training, 1983
Emergency Medical Technician 1, 1986, Recertification 1988
Cardio-pulminary Resusitation, 1988
Cliff Rescue, 24 hours, 1982

INTERESTS:

Volunteer Fire Department Chief
Hiking, backpacking, swimming, gardening, drawing, calligraphy, travel, general aviation.

9/88

10.0 Appendices

Appendix A.
BioSystems Statement of Qualifications

STATEMENT OF QUALIFICATIONS

BioSystems Analysis, Inc.

INTRODUCTION

BioSystems Analysis, Inc. (BioSystems) is a professional services corporation with offices in California, Oregon and Arizona. The company was founded in 1978 to advise utilities, agencies, and private industry on biology, economics, and natural resources. In addition, BioSystems undertakes projects in other disciplines, provided that their major issues are ecological or biological.

Since 1978, BioSystems has grown to a staff of over two dozen professionals in a variety of environmentally based disciplines. BioSystems personnel are highly regarded in their fields and thoroughly experienced in the requirements of consulting. This combination assures the client of a highly credible job performed within the practical constraints of time and budget. Senior staff profiles are presented in Section IV. Bio/Tech Communications, a division of BioSystems Analysis, specializes in technical writing and editing for the energy and environmental sciences. A Statement of Qualifications for the division is available on request.

CAPABILITIES

BioSystems' professional services support multidisciplinary investigation of a wide range of environmental problems. Areas of particular expertise include rare and endangered species; telemetry; biological baseline and ecosystem research; botanical surveys, including rare plant searches; habitat mapping; wetlands, riparian systems, and aquatic ecology; instream flow analyses; thermal modeling; water quality; environmental impact assessments, especially for energy facilities; energy policy and resources; resource economics; and reclamation.

Additionally, BioSystems has established a technical writing and editing division to serve a wide range of communications needs, such as technical reports, planning and regulatory documents, scholarly and popular articles, handbooks, manuals, policy analyses, publicity and marketing materials, presentations and scripts, serial publications, training and curriculum materials, conference proceedings, and computer information.

BioSystems is thoroughly familiar with regulatory standards and requirements for public documents. Our assignments have included environmental assessments and EIS's; Section 404b studies; Endangered Species Act Section 7 consultation and biological assessments; FERC Exhibit W's and Exhibit E's; application of the Instream Flow Incremental Methodology (IFIM) and Habitat Evaluation Procedures (HEP); and use of the Wildlife Habitat Relationship Program (WHRP).

We have successfully completed projects which range in scope from multi-year, million- dollar impact or siting studies for major facilities to highly focused evaluations on short deadlines and limited budgets. BioSystems maintains the necessary equipment and supplies to mount large-scale field investigations on short notice (see Section III). We have conducted field studies large and small throughout the West.

STAFF EXPERTISE

The BioSystems team has on-site experience throughout North America (including Alaska and Canada), and in South America, Africa, and Asia. Senior staff disciplines include aquatic biology (freshwater and marine), botany, ecology, fisheries, wildlife biology (with leading expertise in mammalogy and ornithology), remote sensing, energy, resource economics, resource management, and water quality.

Through our Bio/Tech Communications division, we offer expertise in technical writing, editing, and report production (including graphics art). The Bio/Tech staff is experienced in all aspects of complex research and writing projects, as well as major printing and production assignments.

Central to our approach, we have established working relationships with a broad range of well-respected professionals, often leaders in their fields. We call on these experts for peer review, guidance, and research on a project basis, but approach all assignments with a core of key managers and technical personnel who are well known to our clients.

Offices. BioSystems maintains permanent offices in the Golden Gate National Recreation Area at Fort Cronkhite, in Santa Cruz, California, and in Portland, Oregon. We establish field offices throughout the West on a project basis, as at Mesa, Arizona in conjunction with our 3-year Bald Eagle study for the Bureau of Reclamation.

Computer Resources. BioSystems maintains state-of-the-art computer capabilities for programming, modeling, statistics, database management, communications, graphics, word processing, and project management. We have the expertise, hardware, and software to implement, compile, and execute programs in Fortran-77 and Basic, giving us mainframe capabilities in-house. Each BioSystems office is equipped with several IBM or IBM-compatible work stations which are used to provide full computer support tailored to project requirements.

BioSystems offers ecosystem-level modeling capabilities, including instream temperature modeling, Instream Flow Incremental Methodology, and habitat suitability models such as the U.S. Fish and Wildlife Service Habitat Evaluation Procedures. We are experienced in such statistical treatments as multivariate analyses (e.g., discriminant function and principal component analyses, multiple regression), non-linear curve- fitting, and advanced parametric and non-parametric statistics. Using dBase, LOTUS, and other database programs, we can rapidly create data bases and manipulate and edit files encompassing up to one billion records in up to 128 fields. Further, we have developed a unique and powerful report generation software package for dBase-II and III+.

Computer communications and data acquisition systems are used as needed in conjunction with field data recorders, readers, and remote telemetric monitors for gathering and transmitting environmental measurements. We employ telecommunications to transfer information efficiently within and between offices, and to our clients (we can interface our word-processing with any other ASCII-based system). BioSystems is linked to databases and information systems worldwide through Dialog and other accounts.

We routinely use computers to manage projects and generate reports. Our dedicated word processors can be directly linked through translating software to small word- processing computers used by our professional staff. Graphics preparation is facilitated by word processing, data management, and graphics software and supplemented by our eight-pen color plotter. These capabilities allow us to provide publication-quality computer graphics, including computer-aided design and three-dimensional graphics. Project management draws on critical path scheduling and spreadsheet software--notably LOTUS--for cost and schedule control, progress tracking, and reporting.

Information Resources. BioSystems maintains up-to-date collections of library and field research materials necessary to support most types of projects. A comprehensive technical library covers biology, botany, fisheries and wildlife, ecosystems (e.g., forests, wetlands), ecological theory, regional materials, environmental management, endangered species, human ecology, professional journals, and local, state, and federal surveys and technical documents. In addition, BioSystems has an energy library of comparable depth, covering electric power rates, planning and demand forecasts, state and regional energy scenarios, utility statistics, and technical and environmental data regarding waste heat, cogeneration, energy conservation, and coal, nuclear, solar, geothermal, hydroelectric, wind, and hydrogen energy resources.

Field Equipment. BioSystems is fully equipped to carry out studies of fisheries, wildlife, botany, water quality, and hydrology in environments throughout the West. We possess the necessary field vehicles to travel in rugged, remote terrain while mounting field studies at multiple locations.

Boats, motors, canoes, electroshocking equipment, nets (gill, seine, and dip), and other fisheries sampling gear are at hand to support a full spectrum of fisheries research projects. All equipment needed for IFIM analysis of stream hydrological characteristics is available, as is aquatic invertebrate and vegetation sampling equipment. Aquatic invertebrate samples can be collected using in-stream or benthic samplers. We have complete equipment for limnological and water quality field sampling and direct parameter measurement.

For botanical fieldwork, we retain a wide spectrum of equipment for surveying, determining topographic and physiographic gradients (including automatic leveler), characterizing vegetation stand structure, and performing plot or plotless sampling. Plant identification is aided by a binocular dissecting scope. Wildlife studies are supported by a full range of traps, scopes, and other standard equipment for detecting animals' presence, distribution, and abundance. Importantly, BioSystems offers state-of-the-art biotelemetric monitoring equipment, including transmitters, collars, backpacks, programmable multi-channel scanning receivers, and related accessories.

Report Preparation. BioSystems can handle all phases of report preparation, from typing and graphics to xerography and binding. Our dedicated word processors allow rapid, efficient editing of draft material and are particularly valuable for such chores as bibliographic compilation or the generation of large documents. BioSystems has advanced to the use of high-quality desk top publishing on our PC's linked to a pair of HP LaserJet printers ensuring rapid, versatile, and high-quality document production.

Graphics and Support Services. Complete graphics studios are available at each BioSystems office. The graphics staff is trained in the preparation of maps and overlays, charts, graphs, and biological illustrations. Our Stereo Zoom Transfer Scope--an optical device that superimposes a stereo image taken from aerial photos over a base map of dissimilar scale--allows distortion to be corrected to facilitate accurate mapping of data onto base maps, producing top-quality, high-resolution maps in any scale desired. A full spectrum of support services--printers, photographers, and typesetters--enables us to handle almost any type of illustration.

PRINCIPALS

John C. Garcia, Systems Ecologist

Mr. Garcia, a systems ecologist, specializes in procedures that define natural systems' constraints to and conflicts with development and in information systems concerning natural resources. Mr. Garcia received his M.S. from the University of Washington in 1974 and has consulted since then on more than 50 projects, including a number of large interdisciplinary undertakings. Mr. Garcia, with a fundamental understanding of a wide range of fields, has worked on a variety of resource inventories; recreation, urban, and site plans; park designs; utility corridor analyses; facilities analyses; ecosystem and species modeling; computerized information systems and models; remote sensing of natural resources; and impact, sensitivity, and suitability analyses. Recently, he has been active in stream-corridor, riparian, and Instream Flow Incremental Methodology studies. Mr. Garcia is well versed in resource management and is widely experienced with data collection and field work, data analysis and standardization, and the application of analysis to resolve management conflicts or problems.

Mr. Garcia's extensive management experience includes field and non-field intensive studies. He has managed both biological and interdisciplinary studies, has directed numerous professionals in the fields of life and natural sciences and resource management, besides support personnel such as photointerpreters, statisticians, computer scientists, graphic artists, editors, and others.

Carl Thelander, Wildlife Biologist

Mr. Thelander is a wildlife biologist experienced in raptor research. His M.A. in biology was awarded in 1977 from San Jose State University. He specializes in research on endangered species, particularly birds. His consulting experience ranges over 14 years and includes over 30 large scale projects. Mr. Thelander has conducted or managed surveys and studies of bald eagles, peregrine falcons, golden eagles, and other birds of prey for state and federal agencies at locations throughout California and the West. He is active in endangered species research through his participation in several research institutes (e.g., Peregrine Research Group) and he thoroughly understands the U.S. Fish and Wildlife Service's regulations and procedures governing consultation on endangered species. In other research, he has managed biological investigations for clients in both the public and private sectors, including several inter-disciplinary baseline projects involving major energy facilities.

William B. Davilla, Botanist

Mr. Davilla has over 14 years professional experience, and has consulted and managed over 75 projects since he received his M.A. in Botany from San Jose State University in 1980. As BioSystems' Senior Botanist, he has designed, implemented, and supervised vegetation surveys, habitat characterizations, impact assessments, community sampling and modeling and rare and endangered plant inventories throughout the western United States. Mr. Davilla has developed, overseen, and personally conducted rare and endangered plant investigations throughout California, including the north and south coastal mountains, cismontane valleys, southern desert regions, and the entire range of the Sierra Nevada. During this work, he compiled field survey data and prepared status reports for over 100 rare and endangered species in California, Oregon, and Nevada. Mr. Davilla has extensive management experience with both botanical and interdisciplinary studies focusing on the full spectrum of biological issues in both the public and private sector. As a lecturer in Biology and Botany at San Jose State University and University of California at Santa Cruz, he has taught courses in field ecology, plant taxonomy, botany and forest ecology.

Jeremy Pratt, Energy/Environmental Scientist

Mr. Pratt is an ecologist and energy scientist, with 15 year's experience in managing and conducting scientific research, environmental and energy planning, policy and legislative analysis, and technical writing and editing. He received his M.S. in Energy and Environmental Science from Washington State University in 1979. Mr. Pratt has worked in consulting, nonprofit, legislative, utility, university, and government offices. He has been responsible for project and program management, advising public officials, conducting public meetings, media relations, and representing research programs, projects, and proposals before audiences that have ranged from legislative committees to the public at large. Principal in charge of BioSystems' Bio-Tech Communications division, Mr. Pratt has produced or edited more than 100 technical reports, briefing papers, books, and other documents.

Mr. Pratt's background in ecology emphasizes the impacts of energy facilities and human ecology. In the energy sciences, he has broad experience with electric utilities, conventional power facilities (coal, nuclear, hydro), renewable resources, energy conservation, cogeneration, and district heating. His experience ranges over the Pacific Northwest, the Southwest/Great Basin, and the West Coast.

WILDLIFE BIOLOGISTS

Rodney Jackson, Wildlife Biologist

With over 15 years experience as a wildlife biologist, Mr. Jackson is BioSystems' chief Wildlife Ecologist. Mr. Jackson received an M.A. in Zoology from the University of California at Berkeley and has studied and consulted internationally in Africa, Europe, Asia, and Canada. His specialty is research on endangered mammals and unique ecosystems. A 1981 Rolex laureate, Mr. Jackson recently completed a 4-year intensive field study of the endangered snow leopard in the Nepalese Himalayas. He has assessed biological impacts and constraints for over 35 projects, including residential developments, highways, flood-control facilities, national parks, regional recreation sites, power plants, transmission line corridors, and solid waste disposal facilities. His project management experience encompasses EIR's and EIS's, field-intensive studies of sensitive species and communities, and multi-year baseline research involving controversial issues.

W. Grainger Hunt, Ph.D., Senior Wildlife Ecologist

Dr. Hunt received his Ph.D. in Zoology from the University of Texas in 1970. He has over 25 years of experience with endangered species, primarily birds of prey, and has an extensive academic background in genetics, population biology and ecology, and biochemistry. Dr. Hunt has conducted and supervised state-of-the-art field studies of endangered peregrine falcons, wintering bald eagles, zone-tailed hawks, golden eagles, Harris hawks, aplomado falcons, bat falcons, and other raptors in the Chihuahuan Desert, along the Gulf Coast of Texas and northeastern Mexico, in Latin America, and throughout the West. An experienced commercial pilot, Dr. Hunt is an expert in the application of biotelemetric techniques and aerial radiotracking. Dr. Hunt founded the Chihuahuan Desert Research Institute and served as its Research Director for five years. He has over 10 years experience in management of biological research, with particular background in arid lands.

Susan G. Orloff, Wildlife Biologist

Ms. Orloff specializes in impact analyses, biological assessments for rare and endangered wildlife, and inventories and censuses of wildlife populations. She received her M.A. in biology in 1979 from California State University at Sonoma; since then, she has prepared the wildlife sections of a number of EIR's and identified and described the impacts and mitigations of various development projects. Ms. Orloff has investigated the effects of a major hydroelectric facility on mule deer movements and mortality in central Sierran foothills; developed a system for evaluating the values of stream corridors to fish and wildlife resources in the Pacific Northwest; and managed and conducted several field-intensive projects involving the inventory and assessment of endangered species. She has supervised and conducted a variety of investigations to determine the status and distribution of the endangered San Joaquin kit fox, and she is an authority on the kit fox in its northern range. She also has extensive field experience with radio telemetry, animal capture and restraint, and bird inventories and banding. Ms. Orloff is well versed in habitat inventory and evaluation procedures and has recently been certified in the use of the U.S. Fish and Wildlife Service's Habitat Evaluation Procedure.

Gary G. Ahlborn, Wildlife Biologist

Mr. Ahlborn received his M.S. in Wildlife Biology from New Mexico State University in 1980. He has five years of experience working with the Bureau of Land Management, New Mexico Department of Game and Fish, and as a private biological consultant. Familiar with field techniques and methods, he has sampled and characterized vegetation communities and mammal, bird, amphibian, and reptile populations. Mr. Ahlborn is conversant with various habitat inventory, classification, and evaluation procedures used by federal and state resource management agencies. He has designed and conducted studies to investigate foraging strategies and food and habitat preferences, to establish baseline hematologic values, and to assess and mitigate for energy development and grazing-related impacts. Mr. Ahlborn has extensive experience using radio telemetry in tracking birds and mammals. He has managed both field and literature research projects for our company.

Ron Jackman, Wildlife Biologist

Mr. Jackman has worked as a wildlife biologist on a variety of BioSystems projects since 1980. He surveyed bald and golden eagles as well as other raptors, owls, non-game and riparian birds, waterfowl, small mammals, carnivores, herptofauna, salmon, and inland fish during the Skagit River Bald Eagle study in Washington, the Pit 3, 4, and 5 Project Bald Eagle and Fish study (PGandE), the Wyoming BLM Manual 6602 Wildlife Inventory, a Southern California Edison (SCE) coal power plant EIS, and MX Missile EIS in the southwestern U.S., the Crane Valley Project Study (PGandE), and the Homestake Mine's mitigation in northern California. He supervised field work on three studies of bald eagle ecology: the Pit River Study, the Cache Creek Bald Eagle Study investigating eagle movements and habitat use to mitigate routing of a proposed transmission line, and a bald eagle juvenile migration study, all in northern California. Mr. Jackman is thoroughly familiar with wildlife censusing (including aerial surveys), telemetry, and capture/banding techniques. He has special skills in raptor food habit studies and prey analysis and has published a paper in Auk on food-niche relationships between two owl species in Washington. Mr. Jackman has gained additional experience in habitat characterization, data analysis, technical report writing, and preliminary biological descriptions and proposed studies from several studies for PGandE, SCE, and Mobil Oil Company (San Ardo and Belridge Transmission Corridor Studies, California).

Richard Buckberg, Wildlife Biologist

Mr. Buckberg has worked as a wildlife biologist since 1978. Since joining BioSystems in 1986, he has conducted field studies focusing on sensitive wildlife species. He has worked extensively with San Joaquin kit fox, several sensitive kangaroo rat species, and other sensitive small mammals. He has supervised the wildlife field work on several large scale development projects throughout California, in particular in the San Joaquin Valley and The Geysers region. He is presently conducting detailed wildlife studies for the Coastal Aqueduct Project and a transmission line project in the Salton Sea area. Mr. Buckberg is thoroughly familiar with census and impact assessment techniques for many species of wildlife. He has special skills with the spotted owl, having conducted some of the first spotted owl surveys, and participated in the establishment of spotted owl management areas for the U. S. Forest Service, Pacific Northwest Region. Mr. Buckberg is familiar with raptor capture/banding techniques, having supervised raptor banding stations as part of a migration study. He has conducted specialized studies of wildlife and habitat relationships, and is soon to publish the results of 2 of those studies. He has gained practical experience in wildlife habitat restoration, has written several restoration plans, and conducted monitoring on the efficacy of several habitat restoration projects.

BOTANISTS

Dean Wm. Taylor, Ph.D., Plant Ecologist

Dr. Taylor has fifteen years' experience as a research botanist and instructor of ecology and botany. His recent research experience includes study of mountain ecosystems at the University of Colorado and University of California at Davis, and study of forest ecosystems at Oregon State University. He has studied California flora and vegetation for the U.S. Forest Service and Bureau of Land Management, and has conducted rare plant inventories for numerous clients. Dr. Taylor is a leading expert on the ecology of riparian vegetation in California; he performed riparian studies for the Crane Valley and Haas-Kings River projects. He serves on PGandE's Riparian Habitat Technical Advisory Committee.

Rexford E. Palmer, Ph. D., Botanist

Dr. Palmer has experience on more than 15 field projects in his association with BioSystems since 1981. His responsibilities include vegetation characterization and mapping, rare plant surveys, quantitative vegetation analyses, revegetation projects, and impact analysis and assessment. Dr. Palmer was principle investigator for an on-call special status plant species survey in central Arizona in 1987. He has participated in a two-year field survey of rare, threatened, and endangered plant species along a corridor extending from southern Oregon to central California; and most recently, he has conducted rare plant surveys in the Kettleman Hills in Kings County, California, and Imperial Valley in Imperial County, California.

Glenn Clifton, Botanist

Mr. Clifton has worked extensively as a field botanist over the last eight years, conducting floristic and rare plant surveys throughout northern California, southern Oregon, Nevada, and Arizona. His plant collections currently number over 16,000 specimens, and he has been instrumental in the discovery of two previously undescribed taxa. He aided in the development and refinement of the computer-based Specimen Label Information Directory (SLID), a floristic and rare plant data base housed at Pacific Union College, Angwin. His project experience includes rare plant surveys in serpentine habitats related to the proposed Gasquet-Orleans Road on the Six Rivers National Forest of northwestern California. Mr. Clifton has conducted rare plant surveys over more than 15,000 acres related to the Homestake Mc-Laughlin Project gold mine in Lake, Napa, and Yolo counties. This study, which included more than 10,000 acres of serpentine habitats, resulted in the location of more than 250 previously undocumented rare plant occurrences. Mr. Clifton has additional project experience in the Klamath-Siskiyou region of northwestern California and southwestern Oregon, the Geysers region of Butte and Plumas counties, and the Red Hills of western Tuolumne County. He is an acknowledged expert on the flora of California's North Coast Ranges, particularly Napa, Lake, and Sonoma counties.

WATER RESOURCES AND AQUATIC BIOLOGY

Edward Bianchi, Jr., Ph.D., Aquatic Ecologist

Dr. Bianchi is experienced with instream flow assessments of cold water fishes in tailwater reaches of Sierran streams and with the response of these fishes to thermal stress. He has also been involved with assessing the effect of spills and thermal stress on the population structure, abundance, and distribution of cold water fishes in streams and the effect of fluctuating water levels on cold water and warm water fisheries in reservoirs. Dr. Bianchi has conducted studies involving the population responses of fishes to fluctuating environmental resources including identifying habitat partitioning and key habitat requirements for different size classes of fish. He has a wide range of experience in field collection techniques in both lentic and lotic systems including electrofishing, gill nets, beach seines, food chain analyses, sonic and floy tags, creel censuses, water quality analyses, invertebrate sampling, and estimating fish abundance and distribution.

William Kimmerer, Ph.D., Biological Oceanographer

Dr. Kimmerer is an experienced scientist with substantial knowledge of hydrodynamics and marine ecosystems. He has particular expertise in analyzing and solving problems relating to water pollution and broad capabilities in laboratory management and experimental design. Dr. Kimmerer has published numerous articles on biological oceanography and marine ecology. He has also served as an advisor to government agencies and officials on environmental impacts of a variety of proposed projects. Dr. Kimmerer is a skilled programmer and has written programs for data management, statistical analysis, graphics, and modeling. He is also adept at experimental design and statistical analysis of data. Dr. Kimmerer has participated in numerous projects, including analysis of the effects on coastal and estuarine ecosystems of sewage discharge, dredge spoil disposal, and Ocean Thermal Energy plant operation. He has participated in numerous scientific cruises and expeditions, and is very experienced in handling small boats.

Jeffrey Hagar, Aquatic Ecologist

Mr. Hagar has designed and conducted studies to assess distribution, abundance and health of Sierran stream fish populations and impacts of hydropower development; analyzed the impacts of reservoir operations on warmwater and coldwater fish populations; assessed the effects of reservoir fluctuations on centrarchid spawning success; analyzed fish and water quality impacts resulting from construction and operation of various electric generating facilities; and designed and implemented a research project evaluating the relationship between fish community change in Lake Michigan and predation by introduced salmonids. Mr. Hagar is currently working on development of a flow-based population model for chinook salmon in the Sacramento River and a study of fish communities in the San Francisco Estuary. Mr. Hagar has extensive experience in collection and analysis of fisheries and water quality data, design of fisheries studies, statistical analysis, fish habitat evaluation, environmental impact assessment, and fish population modeling.

Richard L. Bailey, Ph.D., Aquatic Ecologist

Dr. Bailey's background includes over 11 years with state, federal and private agencies conducting environmental assessments. He has specialized in evaluating aquatic ecosystems with an emphasis on fisheries and wetlands. Project management experience includes work on Corps of Engineers dredging EIS's for Moss Landing, Santa Cruz and Humboldt harbors. He also has extensive experience in endangered species consultation and coordination of consultant work on a variety of biological studies. Other major projects he has worked on include an agricultural wastewater disposal study, an evaluation of shoreline changes in Richardson Bay, and the Master and Vegetation Plans for the Warm Springs Dam.

Dr. Bailey participated for two years in U.S. Fish and Wildlife Service consultations on the following endangered species: bald eagle, Florida panther, red-cockaded woodpecker, American alligator, and peregrine falcon. His work resulted in guidelines for the protection of bald eagles and eagle nests in the southeastern states. As team leader of a regional Environmental Assessment Team for the U.S. Dept. of Housing and Urban Development he evaluated vegetation, wetlands, wildlife, coastal issues, disease vectors, and flood plain management for housing development in 10 states.

Nancy W. Hinman, Chemical Oceanographer and Geochemist

Ms. Hinman has seven years' experience in oceanographic and geochemical data collection and analysis. Field experience includes trace metal studies on the Great Salt Marsh in Delaware, benthic sampling in the Central North Pacific, and sampling of exposed sediments (e.g., road cuts) on the Monterey Formation, California. At the Great Salt Marsh she sampled sediments for the University of Delaware using push-core techniques. Her work in the Central North Pacific involved benthic sampling (gravity coring and box coring) at 6,000 meters followed by on-board analysis of nutrients. Research design experience includes a low temperature geochemistry program for the Scripps Institute of Oceanography that emphasizes the relationships between silica digenesis, clay minerals digenesis, and organic maturation; and a model study of an oil spill for the Oregon Graduate Center that focused on the dissolution rate of hydrocarbons into water.

SELECTED REFERENCES

Sheila Byrne, Ellen Yeoman
Department of Engineering Research
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DESCRIPTIONS OF SELECTED PROJECTS

1. **Fossil 1 and 2 Power Plant Siting Studies** (Pacific Gas and Electric Company)

Project management and technical support were provided for the completion of a major biological baseline study of four proposed power plant sites in California's Central Valley. The scope of services included managing a six-person field team on the proposed power plant sites and transmission corridors, collecting and compiling data, preparing the biological portions of PG&E's Application for Certification (AFC), and testifying during the Notice of Intention (NOI) phase.

Field studies involved small mammal capture-recapture studies using live trapping and snap trapping; preparation of voucher specimens; Emlen songbird transects for bird population estimates and Shannon-Weaver diversity indices in all habitats identified; raptor nesting surveys and owl calling; documentation of seasonal changes in species occurrence and abundance in all habitats identified; carnivore scent-post stations and tracking studies; lagomorph flush-count studies; year-round roadside raptor censuses to determine relative abundance and habitat utilization; extensive, state-of-the-art quantitative botanical studies (releve analyses, line transects, and habitat characterization); aquatic organism sampling by electroshocking, seining, and gill netting; plant species collections; preparation of herbarium voucher specimens; and rare and endangered species studies for more than 20 plants, 2 mammals, 5 birds, 2 fish, and 1 insect.

2. **Salt Marsh Harvest Mouse Studies** (Pacific Gas and Electric Company)

The endangered salt marsh harvest mouse, which we encountered in preparing the biological portions of PGandE's Application for Certification (AFC) on the proposed Fossil 1 and 2 power plants, was studied under the Notice of Intent (NOI) phase of licensing. The document meets Section 7 endangered species consultation requirements and reports the feasibility of mitigating for lost habitat. The mouse's on-site distribution and preferred habitat were investigated in detail through capture, mark, and release studies, plus detailed vegetation surveys to characterize the mouse's habitat. The feasibility of mitigation was determined in cooperation with the California Department of Fish and Game and the U.S. Fish and Wildlife Service. Because of the sensitive interaction of the salt marsh harvest mouse with the power plant, PG&E authorized BioSystems to follow up the initial studies with annual monitoring. To date, three years of data have been collected. Studies included a determination of summer and winter mouse population levels, evaluating vegetational trends in salt marsh harvest mouse habitats, and sampling marginal habitats for the presence of the mouse.

3. **Fossil 1 and 2 Transmission Corridor Study** (Pacific Gas and Electric Company)

This four-volume study and atlas present the results of aerial and ground surveys we conducted over approximately 800 linear miles of proposed transmission corridors for 500-kV powerlines associated with PG&E's Fossil 1 and 2 project. The report discusses biological constraints to routing based on our analysis of potential powerline-waterbird interactions; on maps of waterbird habitats, intensity of use, and wetlands; on multiple surveys of waterbirds conducted throughout the winter; and on a waterbird conflict sensitivity analysis. Appropriate mitigation procedures were developed from a literature survey. The atlas consisted of 15 minute habitat and special feature maps.

4. **Skagit River Bald Eagle Study** (Seattle City Light)

The Skagit River of Washington supports one of the largest concentrations of wintering bald eagles in the United States. In a two-year study, BioSystems examined the eagle population, its food resources, and any impacts that might result from construction and operation of the proposed Copper Creek Dam. Staff scientists examined eagle numbers and distribution in relation to the availability of salmon carcasses; habitat requirements of the eagles in relation to existing and future conditions; human disturbance factors; and eagle movements, both locally and over great distances, during their migration to the breeding grounds. The latter aspects required using state-of-the-art radio telemetry techniques and equipment on migrating eagles. BioSystems managers worked at every level, including field research, all phases of public involvement, contract administration for five research contracts, and consultation with the U.S. Fish and Wildlife Service (Section 7) and U.S. Forest Service (Wild and Scenic Rivers). Contracts managed included a documentary film and a pioneering effort to determine eagle food distribution through implanting telemetric equipment in over 100 post-spawning salmon.

5. **Wildlife Inventory of 1.6 Million Acres of Potential Coal Leases** (U.S. Bureau of Land Management)

BioSystems inventoried breeding birds, prairie dogs, herptofauna, and black-footed ferrets in sixteen habitats of the Rock Springs (Wyoming) BLM District. The project required quantitative studies of bird densities and diversity, plus detailed searches for the elusive and endangered black-footed ferret.

6. **California Coal Project's Application for Certification** (Southern California Edison Company)

BioSystems conducted the biological research required to meet the California Energy Commission's Application for Certification process for a proposed coal-fired electric generating facility in the Mojave Desert near Las Vegas. We investigated flora and fauna, especially desert tortoise populations, for the power plant site, pipeline, railroad access corridor, and transmission line corridor. Areas posing conflicts were identified and considered in the planning process.

7. **Ecological Characterization of the Pacific Northwest Coastal Region** (U.S. Fish and Wildlife Service)

BioSystems personnel provided technical direction for this comprehensive interdisciplinary ecological/socioeconomic investigation entailing the integration and characterization of information regarding the Pacific Northwest coastal ecosystems. The study resulted in a widely praised five-volume report and two computerized data sources characterizing the natural resources and processes of the study area, including extensive mapping of natural resources.

Volume 1 provides a conceptualization of the region's ecosystems and their ties to socioeconomic systems. It provides a theoretical framework for critical processes of the Pacific Northwest Coast. Volume 2 examines the critical processes of the Pacific Northwest coast including succession, sediment transport, and hydrology. Also, it provides conceptual and narrative ecosystem models for selected habitats such as salt marsh, eel grass, estuarine, old growth, and western hemlock. The volume describes the regional socioeconomic activities (forestry, fisheries, tourism, transportation, etc.) and identifies any ecological conflicts with them. Volume 3 categorizes and describes all communities of the Northwest Coast from high alpine to continental shelf benthos. Groups of communities are broken into inland, coastal, and pelagic categories, then further subdivided into biological zones (estuarine, headlands, western hemlock, sitka spruce, etc.) and specific communities (subtidal mudflat, intertidal flat, old growth forest, etc.). Characteristic flora and fauna are provided, as are a conceptual ecosystem model and food webs for selected ecosystems. Extensive community composition models are also provided for selected communities. Volume 4 briefly describes and annotates the information available on physical, biological, and socioeconomic processes for each of nine watersheds. Volume 5 develops and describes

the computerized annotated bibliography and annotated species list. The bibliography uses an interactive keyword system evolved from the FAMULUS System. The annotated species list documents species use by biological zone, habitat, season, life stage, abundance, trophic level, and special status for 90-95% of the biomass in each community.

8. **Sacramento Municipal Utility District (SMUD) Geothermal Power Plant Application for Certification** (Sacramento Municipal Utility District, and Stone and Webster Engineers)

BioSystems was selected to conduct all necessary terrestrial biological field studies required in conjunction with SMUD's Application for Certification to the California Energy Commission. The study required vegetation mapping within a one-mile radius of the power plant site, a general wildlife survey, and special studies on threatened, rare, endangered, fully protected, and game species occurring on the site. BioSystems was responsible for the preparation of the biological report and the mitigation and monitoring plans for both the plant site and the transmission corridor.

9. **Raptor Survey of the Grass Creek Resource Area, Wyoming** (U.S. Bureau of Land Management)

A survey was made of 19 species of raptors in the Bighorn Basin, with special emphasis on raptor habitat classification, nest location and mapping, and evaluation of sensitive raptors and habitats. This five-month study required an on-site field team over the entire period.

10. **Antioch Dunes Rehabilitation Project** (Pacific Gas and Electric Company)

This study involved the rehabilitation of a portion of the Antioch Dunes natural area that contains a 500-kV transmission line. The Antioch Dunes provide habitat for two endemic plants, the Antioch evening primrose (*Oenothera deltoides* var. *howellii*) and the Contra Costa wallflower (*Erysimum capitatum* var. *angustatum*), and one butterfly, Lange's metalmark (*Apodemia mormo langei*), that are federally listed endangered species. BioSystems supervised the cleanup of the area and the propagation and replanting of the host plant for Lange's metalmark butterfly.

11. **Alaska Natural Land Systems Studies** (Alaska Federal-State Land Use Planning Commission)

This study consisted of a critique of the natural resources information base developed by the Land Use Planning Commission; a feasibility study of computer-based/remote sensing information systems; a geographic resource identification, quantification, and evaluation through development of a computer analysis system; the identification of biological and physical processes offering constraints and opportunities to land use and land use management; and a geographically specific impact analysis of selected actions.

12. **Warm Springs Dam Recreational Masterplan** (U.S. Army Corps of Engineers and Royston, Hanamoto, Alley and Abey)

As a subcontractor to RHAA, BioSystems was responsible for interfacing biological issues with the recreational aspects of the masterplan. The major biological issue centered on three nearby peregrine falcon eyries, whose presence required Section 7 consultations between the Corps of Engineers and the U.S. Fish and Wildlife Service. BioSystems represented the Corps of Engineers during these hearings. Several mitigations were adopted, and the project was allowed to proceed. Other aspects of the study included developing a game species management plan and a reservoir and tailwater fishery plan.

13. **Statewide Surveys of Bald Eagles, Golden Eagles, and Peregrine Falcons in California** (California Department of Fish and Game)

Surveys of these endangered or protected species were conducted during the breeding seasons of 1973-1976 in order to determine their status. Several papers on aspects of nesting, natural history, and population status were prepared for the Department of Fish and Game.

14. **Studies of North American Peregrine Falcons Wintering in South America** (U.S. Fish and Wildlife Service and Bodega Bay Institute of Pollution Ecology)

BioSystems Analysis, Inc. provided technical field personnel to a contractor studying the status of peregrine falcon populations wintering in South America. The study involved banding peregrine falcons, an endangered species, and taking tissue and blood samples for environmental pollution analyses.

15. **Sumas-Kent Gas Pipeline Siting Studies** (Northwest Pipeline Corporation)

Our personnel conducted a biotic assessment of a proposed gas pipeline route in Oregon. Tasks included description of wildlife and vegetation along the corridor, assessment of biotic impacts, establishment of mitigating measures, and definition of additional required studies. The staff gave expert testimony before the Federal Power Commission.

16. **Alaska Liquid Natural Gas Terminal and Pipeline Routing Study** (U.S. Federal Power Commission)

This study identifies and characterizes natural features constraining pipeline routing and terminal selection, describes impacts, and suggests mitigation measures.

17. **Pacifica General Plan** (City of Pacifica, California)

In this study, we determined biological resources within the City of Pacifica and prepared a plan to protect important biological habitats, including intertidal areas. Our work emphasizes critical habitats for rare and endangered plants.

18. **Red Rock Canyonlands Master Plan** (Nevada State Parks/U.S. Bureau of Land Management)

BioSystems personnel evaluated the biological resources and constraints of the 64,000-acre Red Rock Canyonlands Park near Las Vegas. Special attention was given to developing recreational use patterns and management guidelines that afforded protection for sensitive springs and streams and desert bighorn habitat.

19. **Golden Gate National Recreation Area Planning Study** (U.S. National Park Service)

Our staff assisted a planning firm in developing recreation options for the southern portions of the Golden Gate National Recreation Area. Wildlife resources were described and mapped, and sensitive habitats identified. Guidelines were developed with reference to native habitats, rare and endangered plant populations, and sensitive wildlife breeding and feeding areas.

20. **Mouth of Columbia River Recreation Plan** (U.S. Army Corps of Engineers)

BioSystems personnel conducted an environmental analysis and prepared master plans for five recreation sites totalling 3,100 acres at the mouth of the Columbia River in Washington and Oregon.

21. **Study of Sensitive Plant Species on the Red Hills Management Area, Tuolumne County, California** (U.S. Bureau of Land Management)

We conducted a quantitative sensitive plant study over 7,100 acres of serpentine habitats in the Red Hills of western Tuolumne County. Stratified random quadrat sampling was used to estimate absolute density over the Red Hills Management Area for three BLM sensitive species—Rawhide Hill onion (*Allium sanbomii* var. *tuolumnense*), Red Hills soaproot (*Chlorogalum grandiflorum*), and Congdon's lomatium (*Lomatium congdonii*). The distribution of each species was mapped over the study area in five density classes. Three occurrences were documented within the Red Hills Management Area for Layne's butterweed (*Senecio layneae*), a state-listed rare plant species which was found prior to this study only in El Dorado County.

22. **U.S. 395 Corridor EIS** (Nevada State Highways Department)

This 18-month study analyzed the impact of upgrading U.S. Highway 395 between Carson City and Reno. BioSystems scientists assessed the effects on wildlife along five alternative corridors, with particular emphasis on migratory deer herds, wintering raptors, and shorebirds.

23. **Marysville Dam EIS** (U.S. Army Corps of Engineers)

Our personnel assessed the impacts on fisheries and wildlife of a multipurpose reservoir on the Yuba River. The effects on salmon spawning and deer habitat were of particular public and agency concern.

24. **Lewis River Grain Terminal Assessment** (Parametrix)

BioSystems completed a biological evaluation of the proposed Lewis River grain terminal at the confluence with the Columbia River, Washington. The study included habitat mapping, assessment of issues, and development of management and mitigation procedures, especially for sensitive riparian communities.

25. **MX Missile Base Biological Assessment** (U.S. Air Force, via EDAW)

We were responsible for providing biological constraint information to the MX Operational Base interdisciplinary planning team and for assessing the impacts associated with proposed facilities at five sites in New Mexico, Nevada, and Utah. Requirements included literature reviews, terrestrial vertebrate baseline studies, vegetation characterization and mapping, and specific studies on species of concern, including desert tortoise, desert bighorn sheep, mule deer, Rocky Mountain elk, feral horses and burros, pronghorn antelope, black-footed ferret, bobcat, kit fox, mountain lion, Utah prairie dog, spotted bat, gila monster, lesser sandhill crane, lesser prairie chicken, sage grouse, and six species of raptors. The team developed the biological portions of a comprehensive resource management plan aimed at reducing conflicts and preserving natural resources. In addition, it provided complete terrestrial baseline information, including soils classification; plant community characterization and mapping; abundance and distribution of small mammals, lagomorphs, large mammals, herptofauna, and avifauna; and 22 integrated biological community definitions at the five sites. Unique communities, habitats, and special features were treated in depth.

26. **MX Transportation Corridor Assessment** (Natural Resource Consultants, Inc.)

Our team was subcontracted to assess the effects of downslope drainage and roadside alterations on wildlife populations in Utah and Nevada. The abundance and diversity of birds, small mammals, and lizards were compared using paired transects. Pellet-scat plots and scent station transects were used to assess the effect of paved roadways on the activity and abundance of ungulates and carnivores.

27. **Peregrine Falcon Migration and Habitat Use** (U.S. Fish and Wildlife Service and National Parks Service)

We captured, radio-tagged, released, and tracked 12 peregrine falcons on Padre Island, Texas. Habitat preference and prey utilization were quantified. One individual peregrine was tracked from Padre Island to northern Michigan over a twelve- day period.

28. **Six Rivers National Forest Rare Plant Survey** (U.S. Forest Service)

BioSystems personnel conducted an ecological investigation of *Hastingsia bracteosa* (large-leafed rush lily) and *Erigeron delicatus* (streamside daisy) to document their status in the forest district and to verify their total range. Historical and potential habitats were surveyed, herbaria checked, and literature reviewed.

29. **Diablo Canyon Nuclear Power Plant Early Warning Siren System Rare Plant Survey** (Pacific Gas and Electric Company)

Fifty siren locations in San Luis Obispo County were included in our survey for rare and endangered plants in order to determine sensitive tower sites and avoid adverse impacts where possible. BioSystems personnel also conducted a literature survey and herbaria check for more than 20 species.

30. **Homestake Mine Rare Plant Survey** (D'Appolonia)

This study presents the results of our intensive field survey of over 10,000 acres of serpentine-dominated land for sensitive plant species. The study maps localities, characterizes populations, and identifies probable project-related impacts. In addition, it includes a full checklist of plants for all habitat types in the detailed study area.

31. **Bonny Doon Ranch Assessment** (County of Santa Cruz, California)

We mapped and characterized habitat types on a 500-acre site proposed for vineyard and residential development. Fieldwork emphasized locating and mapping the extent of three rare and endangered plants and six unique plant and animal species. Impacts were identified, and a plan was prepared addressing several alternative land use scenarios. Our report was well accepted by all parties to this controversial project.

32. **Sacramento Municipal Utility District (SMUD) Geothermal Revegetation** (Stone and Webster Engineers)

Our company performed a revegetation and monitoring program of SMUDGEO #1 geothermal power plant in the Geysers of Sonoma County, California. Tasks included collection, propagation, and planting of native adapted plant stock and the design and supervision of a hydroseeding erosion control program.

33. **Baylands Master Plan** (City of Palo Alto, California)

BioSystems personnel, assisting in the development of guidelines to protect environmentally sensitive areas, mapped and characterized rare and endangered species habitat and waterbird feeding areas. Biological concerns and constraints played a major role in determining optimal land uses and flood control management.

34. **Rare and Endangered Plant Inventories of the Inland Marine Sand Deposits in Santa Cruz County** (County of Santa Cruz, California)

Our staff conducted a number of field reconnaissances, assessments, and inventories of designated rare and endangered plant species for the County of Santa Cruz. We identified, described, and evaluated impacts and mitigation measures.

35. **Survey of Abram's Cypress Stands on Butano Ridge** (California Natural Areas Coordinating Council)

This biological assessment of the Abram's cypress stands on Butano Ridge was made to determine its suitability for inclusion in an inventory of natural areas.

36. **Harbor Bay Isle** (Royston, Hanamoto, Alley and Abey)

BioSystems personnel investigated a housing development's potential impacts on the California least tern, an endangered species in the state. We suggested means of minimizing conflicts or adverse impacts.

37. **Owens Valley Groundwater Pumping EIR** (County of Inyo, California)

The County of Inyo contracted us to review the EIR on increased groundwater pumping in the Owens Valley with reference to the potential effects on wildlife. BioSystems also provided expert legal testimony for the County on the effects of water withdrawal on wildlife.

38. **Grand View Park EIR** (City of San Francisco, California)

This report identifies and describes the effects of a proposed residential development on the rare dune tansy (*Tanacetum camphoratum*).

39. **Gold Beach, Oregon Development Study** (Royston, Hanamoto, Alley and Abey)

BioSystems conducted a field survey of 1,200 acres located near the mouth of Oregon's Rogue River to determine the biological constraints of a proposed low-density housing project. We prepared a report and a constraints map to assist the developer in avoiding major biological degradation and impacts.

40. Alhambra Creek (U.S. Army Corps of Engineers)

Our biotic assessment of Alhambra Creek, near Martinez, California, describes sensitive riparian and wetland habitats that could be adversely affected by streambed channelization, and it suggests measures to protect these resources. Five river reaches are described, from tidal slough to upstream freshwater reaches. In addition to the wetlands and riparian vegetation, associated terrestrial vegetation is identified. Inventories of aquatic life, wildlife, and rare and endangered species are presented, and all plant, animal, and community elements are related to emerging local and federal plans for floodplain management and waterway protection.

41. Radio-Tracking the Snow Leopard in the Himalayas (1981 Rolex Award for Enterprise to Rodney M. Jackson)

Our senior wildlife ecologist, 1981 Rolex Laureate Rodney Jackson, recently managed this multi-year field study of the rare and endangered snow leopard in the Nepal Himalaya. The study attempted the live-capture and radio-collaring of five snow leopards in the Kanjiroba Himal of West Nepal, and the investigation of their movements, home range, habitat preferences and use patterns, predator-prey relationships, and aspects of social organization. The study included an eight-month tracking period of tagged leopards supplemented by intensive tracking of sign, analysis of scats and kills, censusing of major prey species, habitat characterization, and interviews with local residents. The study was designed to estimate the relative abundance of the endangered carnivore in the Himalaya, and to determine the size and determinative features of its home range, and to discover its nomadic and territorial behavior. A management plan, under development in consultation with Nepali officials, will identify critical ecological requirements for the snow leopard and its prey, evaluate environmental conflicts and trade-offs, identify conservation opportunities, and provide a basis for follow-up research. The research builds on a previous study conducted by Mr. Jackson for the Government of Nepal in 1976-77. See *National Geographic*, June 1986

42. Peregrine Falcon Nesting Cliff Evaluation (U.S. Forest Service)

Here we conducted an evaluation of ten potential peregrine nesting cliffs in the Six Rivers National Forest, and we installed an artificial nesting platform on one of the cliffs.

43. Rare Plant Survey (County of Marin, California)

This field survey and literature search were conducted for rare and endangered plants on a proposed land division in central Marin County.

44. Salt Drift Studies (Pacific Gas and Electric)

This state-of-the-art study of the effects on vegetation of salts contained in cooling tower drift was performed in connection with PG&E's proposed Montezuma power plant. Previous studies had been performed using planted test plots, but this study utilized in situ vegetation. We applied a series of salt concentrations plus controls of water to the vegetation plots over the entire growing season, analyzed samples for surface salt and salts incorporated into the tissues, and recorded visual observations of leaf damage caused by salts.

45. **Botanical and Wildlife Studies in Support of EIR for Lawrence Livermore National Laboratory Site 300** (Science Applications, Inc.)

BioSystems conducted the biological research required for the EIR for proposed Site 300 development. For rare plants and special status wildlife, we performed literature and data base reviews and intensive field surveys. We characterized and mapped vegetation and sensitive habitats. The wildlife species of primary concern is the San Joaquin kit fox; studies for this species included extensive ground searching for kit fox dens, monitoring of scent stations and track pads, and night spotlighting surveys. A final technical report was prepared describing findings, analysis, project impacts, and proposed mitigation measures; in addition, we composed draft biological sections of the EIR.

46. **Sequim Bay EIS** (U.S. Army Corps of Engineers)

This study presents the potential impacts of a proposed marina at Pitship Point, Sequim Bay (Clallam County, Washington) on bald eagles and peregrine falcons.

47. **Energy-Related Use Conflicts for the Columbia River Estuary** (U.S. Fish and Wildlife Service)

Our state-of-the-art report provides a comprehensive reference work for the fish and wildlife managers who will confront energy development over the next 25 years in this highly sensitive area. The study projects and maps energy-related developments in the estuary, summarizes development impacts upon fish and wildlife in estuarine systems, models developments in six estuarine ecosystems, makes detailed accounts of forest and industrial trends along with detailed assessment of energy-related technologies.

48. **Survey of Raptor Nesting Cliff Habitat on Three National Forests in California** (U.S. Forest Service)

We made helicopter, fixed-wing airplane, and ground searches of approximately 100 potential raptor nesting cliffs in the Angeles, Los Padres, and San Bernardino National Forests for the U.S. Forest Service. Species of special interest were the California condor, golden eagle, peregrine falcon, and prairie falcon. Management recommendations were developed.

49. **Habitat Survey for the Rare and Endangered *Bensoniella oregana* in Humboldt County** (U.S. Forest Service, Six Rivers National Forest)

Staff botanists surveyed 72 miles of potential stream habitat for the rare plant *Bensoniella oregana* in the Six Rivers National Forest and surrounding private lands in Humboldt County. This project required identification and collection of this species in the field and characterization of its ecological requirements. We submitted recommendations for its protection and management in proposed timber land.

50. **Baseline Environmental Description and Impact Studies of the Geothermal Resources International, Inc. A-2 Leasehold, Lake and Sonoma Counties, California** (Stone and Webster Engineers)

Our team conducted baseline studies of soils, vegetation, and wildlife related to the Application for Certification for the Central California Power Agency's No. 1 Coldwater Creek Geothermal Power Plant, located in the Geysers region of northeastern Sonoma County. We characterized and mapped vegetation and habitat, surveyed for rare plants and sensitive wildlife, and identified critical and sensitive habitats. The California Wildlife Habitat Relationships Program (WHRP) was used to evaluate habitat suitability for sensitive, recreational, and commercial wildlife species. Our studies addressed potential impacts on soils, vegetation, and wildlife related to construction and operation of a steamfield within the GRI A-2 Leasehold.

51. **California Wildlife Habitat Relationships System** (U.S. Forest Service)

This project, funded by the U.S. Forest Service and California Department of Fish and Game, included developing and preparing a computer-based classification system for 109 terrestrial vertebrates in California. Our staff wrote concise narratives of species' life history and habitat requirements. We developed matrices for these species, relating their life requisites (reproduction, cover, feeding) to various size and age classes and percent canopy closures of 50 major habitats. Species were also related to specific habitat elements (diet elements, edaphic elements, edge elements, etc.). This classification system provides natural resources decision-makers with current information on wildlife habitat capabilities and the predicted consequences to wildlife of land resource management alternatives.

52. **A Comparative Analysis of Anadromous Salmonid Stocks and Possible Cause for their Population Decline in Selected Watersheds of the Eastern Pacific Coast** (Northwest Power Planning Council)

We completed an analysis of past and current trends for anadromous salmonid populations of Southeast Alaska, Fraser, Rogue, Klamath, Trinity, and Sacramento Rivers. Factors evaluated were dams, harvest, land use, and forestry practices. We compared population trends and causes of the salmonids' decline to those in the Columbia River System, showing parallels between them and discussing implications to management.

53. **Development of Stream Corridor Inventory and Evaluation System (SCIES)** (U.S. Fish and Wildlife Service)

Our scientists developed a methodology for assessing the value of stream and riparian areas to fish and wildlife that can be used to identify high-value areas and to inventory riparian ecosystems on basin-wide scales. Based on a review of current inventory methods, a way to inventory and evaluate stream corridors was developed that allows fish and wildlife managers to incorporate the results of IFG, HEP, and HSI information and to build on existing classification systems in determining value. Principally, SCIES was designed to provide fish and wildlife managers with a flexible, cost-effective, and comprehensive tool that could adjust to specific project conditions and objectives, but still yield information comparable across geographic regions.

54. **Evaluation of Fish and Wildlife Potential of Stuart Creek** (Bouverie Audubon Preserve)

Using the Stream Corridor Inventory and Evaluation System that we developed for the USFWS, we evaluated the habitat value of the Stuart Creek stream corridor on the Bouverie Audubon Preserve in Sonoma County, California. Aerial photography of the site was interpreted using a Stereo Zoom Transfer Scope, vegetation was mapped, and terrestrial and aquatic habitat parameters were measured, mapped, and evaluated to develop a reach-by-reach assessment of habitat and management potential for the stream.

55. **Wetlands Inventory of Skagit County, Washington** (Washington State Department of Ecology)

John Garcia coordinated an extensive inventory of Skagit County wetlands for the Washington State Department of Ecology. Wetlands in both coastal and inland areas of the county were typed, delineated, and mapped, and their relative value to fish and wildlife determined. A computerized data base was developed to monitor changes in wetlands, as well as to describe size, ownership, present land use, land zoning, life zone, elevation, soil type, and other attributes.

56. **Rare Plant Survey of Proposed De Sabla-Centerville Project Improvements (FERC 803) and Existing Rock Creek-Cresta Project (FERC 1962), Butte and Plumas Counties, California** (Pacific Gas and Electric Company)

Staff botanists conducted site-specific rare plant surveys related to licensing the proposed improvements to (1) the De Sabla-Centerville hydroelectric project in the Butte Creek and West Fork Feather River drainages, and (2) the Rock Creek-Cresta Project in the canyon of the North Fork Feather River. We surveyed existing tower sites of the Nos. 1 and 2 Rock Creek-Rio Oso 230 kV transmission lines on lands administered by the U.S. Forest Service, we documented and mapped rare plant occurrences, and we addressed anticipated project impacts. A vegetation characterization of each tower site was completed using the Braun-Blanquet releve method.

57. **Comprehensive Floodplain Management Program** (City of Pullman, Washington)

We researched and outlined a comprehensive program of floodplain planning for the City of Pullman and presented it to the City Council. The program incorporated such features as an emergency preparedness and evacuation plan; flood insurance for merchants and residents; an early-warning system; floodplain zoning, subdivision ordinances, and building codes; physical flood control measures for the South Fork Palouse River; a public-awareness program; flood water storage; and a floodproofing plan for existing structures. A broadly representative Task Force for Floodplain Management and a City Office of the Floodplain Coordinator were formed to implement the program.

58. **Development of Whitman County Rural Residential, Rural Community Center, and Rural Commercial Zoning Ordinances** (Whitman County, Washington, Regional Planning Council)

Two rural Washington communities, Steptoe and Thornton, were inventoried for physical features, land use, and residents' attitudes on zoning ordinances. Aerial photographs were used for mapping all features; however, extensive ground inventories were also undertaken. Attitudes were surveyed using a door-to-door method, covering over 90% of local residences. New rural zones were devised to meet local priorities and preserve a rural lifestyle while allowing development on lots the size of those found in incorporated communities within the County. The zones were designed to apply to all 13 existing unincorporated towns then located in the Agricultural Zone (20-acre minimum building site). In addition to the mapping of zones and the drafting of a zoning ordinance, an EIS was completed on the zones, presentations were made to the public and to county commissioners, and public hearings were held in Steptoe and Thornton.

59. **The Impacts of Development on a Small Watershed** (National Science Foundation)

John Garcia was a major participant in a two-year multidisciplinary study that inventoried and catalogued the effects of urbanization on a small watershed. The project compared the relatively developed Kelsy Creek watershed to the relatively pristine Cole Creek watershed. Parameters investigated included land use, land value, instream and near-stream development, habitat and vegetation types, benthic invertebrates, fish and wildlife, runoff, erosion, impervious surface, sediment, and water quality. The study resulted in an erosion control ordinance and an impervious surface tax to pay for runoff management.

69. **Sierra Nevada Wilderness Impact Study** (Sierra Club National Outings Committee and Yosemite National Park)

Our team conducted a five-year study on the impact of human recreational activities on subalpine forest ecosystems of the Sierra Nevada. We developed and conducted experiments to characterize forest productivity and biomass, woodlitter regeneration, and firewood consumption in the wilderness area of the Sierra Nevada. Impacts were identified and management procedures developed.

70. **Evaluation of the Releve Method for Characterization of Stream Diversion Effects on Riparian Vegetation** (Pacific Gas and Electric Company)

BioSystems conducted extensive, reconnaissance-level vegetation sampling along streams within the upper San Joaquin River watershed in the central Sierra Nevada, California. Primarily, these studies were designed to determine the effectiveness of using releve sampling techniques as a rapid, initial method for assessing ecological effects of streamflow modifications on riparian habitat. The releve data were transferred to a computerized data base to facilitate statistical comparisons of present vegetation conditions above and below diversion points and to control for pre-existing vegetation differences (e.g., those related to physiographic patterns).

71. **North Fork Feather River Small Hydro Endangered Species Studies for FERC Application Exibit E's** (Pacific Gas and Electric)

BioSystems completed rare plant surveys and assessment of impacts and mitigation for five proposed small hydroelectric projects in the California Sierra as well as habitat analyses on selected projects.

72. **River Corridor Habitat and Vegetation Analysis** (U.S. Army Corps of Engineers, Washington School of Forestry)

Our personnel completed vegetation analysis and wildlife habitat mapping of the Columbia River corridor from Hanford Power site to the Canadian border. We evaluated and mapped habitats using remote-sensing techniques. The study yielded measurements of the impact of changing water levels on the affected ecosystems.

73. **Biological Assessments, Ute Mountain, Ute Indian Reservation** (U.S. Bureau of Indian Affairs)

Our company conducted two Biological Assessments in connection with the proposed Ute Mountain Strip Coal Mining Operations in San Juan County, New Mexico. In compliance with section 7(c) of the Endangered Species Act of 1973, species-specific biological assessments were conducted on two federally listed species, the endangered black-footed ferret (Mustela nigripes), and the threatened Mesa Verde cactus (Sclerocactus mesae-verdae). We inspected the proposed coal lease areas on-site to determine the presence of Mesa Verde cactus and black-footed ferrets and to identify and document suitable habitat for both species. We interviewed recognized state, federal, and academic experts on the ecology and status of the Mesa Verde cactus and black-footed ferret and compiled an annotated literature review on each species, the species' ecology, natural history, known responses to impacts, and overall regional and site-specific status. Our staff reviewed and analyzed the direct and cumulative effects of the proposed coal strip mining operations on each species. Alternative actions to coal development and to phases of mining operations were evaluated to avoid, compensate, and mitigate for adverse impacts on each species. Our report documents the procedures and results of the biological assessments.

64. **Feasibility Analysis of a Hydrogen-Hydroelectric Energy System for Holden Village, Washington** (Holden Village and WSU Environmental Research Center)

Jeremy Pratt evaluated the applicability of installing a hydrogen conversion system at a small seasonal hydroelectric project in North-Central Washington. Preliminary plans were developed to demonstrate the technology at Holden Village. The team investigated the potential for utilization of excess summer-peaking hydropower from a 360 kW capacity plant to electrolyze water, providing hydrogen fuel to displace diesel oil for winter space heating. An extensive literature review was conducted to select candidate technologies for conversion and hydrogen storage and to identify system constraints; an initial energy budget for Holden Village was outlined, addressing seasonal energy requirements and supply capacity for each building; and a financing strategy was established to pursue funds for detailed engineering and design.

65. **Evaluation of Renewable Resource Technologies in the Pacific Northwest** (Washington State University Environmental Research Center)

Here we assessed the feasibility of using several renewable resources in various applications. We evaluated the opportunity for integrating intermittent, renewable resources (wind and solar electric systems) with the Federal Columbia River Hydroelectric Power System, and for utilizing storage reservoirs as a means of leveling supply. Local weather's influence on reliability of solar thermal systems and on associated thermal storage requirements was analyzed for Seattle-Tacoma, Washington, and Medford, Oregon, in terms of the frequency of time sequences of various lengths in which insolation was 75%, 60%, and 50% of the five-year monthly average. Hot dry rock geothermal development potential was investigated and potential indicators of environmental impact were examined. These studies were largely conducted on short- term, highly focused contracts.

66. **Soquel Creek** (County of Santa Cruz, California)

We conducted a biological resource survey of Soquel Creek for the City of Capitola, inventoried wildlife and vegetation along a one-mile section of creek, and described and mapped the distribution of riparian and floodplain habitats.

67. **Los Osos Dam Site** (County of Santa Clara, California)

Our scientists described and mapped the biotic communities of the Canada de Los Osos proposed reservoir site, and prepared a checklist of plants of the reservoir area.

68. **Felton Quarry Vegetation Assessment** (County of Santa Cruz, California)

Our company conducted a survey of existing vegetation in a 240-acre quarry expansion area. The report identifies and maps existing biotic communities, includes a checklist of plants, assesses impacts from mining of the entire site, and proposes mitigation. We evaluate the potential for revegetation of the site, prepare a revegetation plan, and locate and map areas of critical concern and rare and endangered plant populations.

60. Vegetation and Rare Plant Survey of the Royal-Mountain King Gold Project, Calaveras County, California (NERCO Minerals Company)

Our botanists conducted a vegetation and rare plant survey on a 1,600-acre leasehold in the Sierra Nevada foothills near Copperopolis. Rare plant occurrences were documented and mapped, and anticipated impacts related to development of the Royal-Mountain King gold mine were addressed.

61. Preliminary Energy Resources Report Data Base Environmental Assessment (Seattle City Light)

This report condenses into clear, graphic form the physical, biological, and socioeconomic impacts of over 100 standard and alternative energy generating plants. It projects short-term and long-term impacts and benefits, assesses the outlook for mitigation, and identifies affected or interested groups (farmers, ranchers, Native Americans, etc.). Environmental-impact matrices were prepared for 113 electric- energy generation, conservation, and offset projects, including existing facilities, facilities under construction, and facilities at a variety of planning stages. These included 33 hydroelectric projects, 29 conservation projects, 9 fossil-fueled plants and 9 nuclear conventional central-station plants, as well as solar thermal and solar electric, geothermal, cogeneration, wind biomass, refuse-fired, ocean thermal, wave-powered, nuclear fusion, heat pump, and load management and storage projects. Impacts were evaluated for the physical environment (air, water, land), biological environment (wildlife, fisheries, endangered species), and human environment (socioeconomic, quality of life).

62. Comparison of Geothermal Energy with Coal, Oil, and Natural Gas for Selected Uses (U.S. Department of Energy)

This analysis compares the environmental effects and energy efficiencies of geothermal energy (hydrothermal), western and eastern coal, oil, and natural gas supply systems for space heating, process heat, and electric power. Investigation proceeds through all fuel cycle stages from development (e.g., strip mining, well drilling) through conversion, transportation, secondary conversion (if any), distribution, use, and waste disposal. Effects considered included air emissions, water residuals, noise, land disturbance, visual impacts, and trace toxic residuals. Environmental effects were compared per unit of end use supplied, e.g., grams of H2S released per million BTU delivered. The energy efficiencies were computed as second law efficiencies, which compare amounts of end use actually delivered to the amounts that could be delivered if the energy resources were utilized in theoretically optimum ways.

63. Comparison of Coal-fired Power Systems in Waste Heat Applications in Tacoma, Washington (U.S. Department of Energy)

Jeremy Pratt completed this technical analysis and report while on fellowship from the U.S. Department of Energy at Washington State University. The project designs and analyzes urban-sited coal-fired power systems linked to residential users consuming waste heat. System design and modeling for 24 configurations includes thermodynamic analysis of system efficiencies based on engineering criteria for steam conditions at the turbine and heat exchanger; district heating and electrical distribution system design and thermodynamic analysis; end-use analysis; characterization of environmental impacts on land, air, and water; and levelized cost comparison. End-use analysis covers waste heat supply of both space heating and domestic hot water loads for two types of building (garden apartments and detached single dwellings), each with several levels of insulation as well as alternative indoor temperatures and hotwater supply temperatures.

74. **Biotic Survey of the Gerald L. Anchor Property** (County of Santa Cruz, California)

BioSystems conducted a detailed biological assessment related to a proposed land division and residential development on a 150-acre parcel in southern Santa Cruz County. Vegetation/habitat types on the property were characterized and mapped. We particularly emphasized mapping the distribution and range of three sensitive plant species and two sensitive habitat types. Anticipated impacts related to the proposed project were addressed, and management recommendations were developed to mitigate for potential negative impacts.

75. **Feasibility Assessment of Hydrogen Energy Production Using Surplus Hydro- electricity** (Bonneville Power Administration)

Company staff conducted a preliminary technical and economic feasibility analysis of electrolytic hydrogen production. Our state-of-the-art review of fuel cells and electrolyzers contains technology assessments of electrolyzers, compressor and storage equipment, transportation technology, and hydrogen compatibility with existing Northwest pipelines and equipment. Using these data, we present an economic feasibility analysis and calculate the production cost of hydrogen. We outline the relationships between cost of hydrogen and type of electrolyzer, annual utilization factor, price and availability of power, level of installed capacity, and cost of capital; and we assess the cost-competitiveness of electrolytic hydrogen with other fuels and with steam-reformed hydrogen. Finally, we present a preliminary survey of Northwest hydrogen markets and concerns.

76. **Rare and Endangered Wildlife Survey** (Windmaster, Inc.)

Susan Orloff determined the presence and location of rare and endangered wildlife species within the proposed windfarm development area in Contra Costa and Alameda counties. Principal species of concern were the San Joaquin kit fox and the Alameda striped racer.

77. **Analysis of Environmental Costs and Benefits: A Case Study of the Sultan Hydropower Facility** (Bonneville Power Administration)

BioSystems provided BPA with one of a series of case studies of environmental costs for different kinds of energy facilities. Using the Sultan project, we developed and tested economic methodologies for costing the environmental impacts of a hydroelectric dam. This required reviewing existing environmental impacts of the dam, selecting significant impacts for costing, defining linkages between impacts and economic values, developing or adapting methods to measure environmental costs in economic terms, and quantifying levelized dollar costs. Existing data were used to value recreation, wildlife productivity, black-tailed deer, furbearers, commercial timber, and human health impacts from operating the dam. Extensive data were gathered to develop costs for impacts on whitewater kayaking and old-growth forests.

78. **A Critical Review of the Instream Flow Incremental Methodology** (Southern California Edison Company)

We completed a state-of-the-art review of the U.S. Fish and Wildlife Service's Instream Flow Incremental Methodology to determine its adequacy for establishing flow requirements for resident salmonids in California. In doing so, we explained the methodology and assumptions, reviewed validation studies, outlined desirable research areas, and detailed constraints in the use of the methodology.

79. **Rare and Endangered Plant and Animal Surveys for Proposed Windfarm Development** (Altamont Energy Corporation, Fayette Manufacturing Corporation, FloWind Corporation, Howden Windparks, NFC Energy, U.S. Windpower, WTG Windfarm)

We conducted field reconnaissances, impact assessments, and inventories of designated rare and endangered plant and animal species for a number of proposed windfarm developments in Alameda, Contra Costa, and San Joaquin Counties. These studies primarily focused on thorough ground searches for dens and night spotlighting for the San Joaquin kit fox; literature and data base reviews, and field surveys for rare plants; and determination of suitable habitat for other special status wildlife species.

80. **IFG-4 Analysis for the Proposed Bishop Creek #1** (Southern California Edison Company)

Our staff completed an IFG-4 alternative to the U.S. Fish and Wildlife PHABSIM program to determine the optimum flow conditions for resident trout of the north fork of Bishop Creek. Effects of flooding, monthly mean flows, and high and low mean flows were all reviewed in terms of their effects on physical carrying capacity for fish.

81. **FERC Exhibit E, Oak Creek** (Fort Independence Indian Reservation)

BioSystems completed a FERC Exhibit E for a proposed hydroelectric facility on Oak Creek, California. Studies include IFG-4 analysis, fish population survey, rare plant survey, analysis of flow effects on riparian communities, and project effects on wildlife.

82. **Mono Creek Water Quality and Benthic Invertebrate Study** (Southern California Edison Company)

BioSystems documented and analyzed the effect of iron contamination from Vermillion Dam drain water on benthic invertebrates in the Mono Creek drainage. We sampled eight sites were sampled for benthic invertebrates and water quality during different seasons, assessed impacts to fisheries, and suggested appropriate mitigation measures.

83. **Geothermal Baseline Monitoring for the Mt. Baker Geothermal Development Area** (Seattle City Light)

Our company was the prime contractor to develop and carry out the baseline environmental monitoring program for the proposed geothermal development in the Mt. Baker Geothermal Resource Area. The program involved a wide range of natural resources including air quality, water quality, socioeconomics, Native Americans, fisheries, wildlife, and vegetation. Telemetric studies were conducted on spotted owls and martens.

84. **Stream Survey for the Mt. Baker National Forest** (U.S. Forest Service)

BioSystems completed detailed biological surveys focusing on fish habitat in 100 miles of stream in the Skagit and Nisqually upper watersheds of Washington State. The surveys included such aspects as spawning quality, stream stability, pool quality, juvenile and fry rearing potential, diversions, sediment, cover, and species.

85. **SMUDGEO Terrestrial Biological Study** (Aminoil USA)

We conducted a biological baseline study for the proposed SMUDGEO #1 geothermal power plant in northern California. We identified and analyzed critical and sensitive habitat elements and characterized vertebrate wildlife using qualitative and quantitative field techniques.

86. **IFG-4 Analysis of Mono Creek** (Southern California Edison Company)

Our staff completed an IFG-4 analysis on Mono Creek in the southern Sierra to ascertain the effects on fisheries of modified flows from the proposed addition to the Vermilion Valley hydroelectric facility.

87. **Baseline Monitoring Study of Marin Headlands** (National Park Service)

BioSystems personnel performed an ecological characterization that documented plant, small mammal, and avifauna relationships for dominant terrestrial communities in the Marin Headlands (Golden Gate National Recreation Area). Tasks include raptor surveys, small mammal trapping, waterbird surveys of Rodeo Lagoon, and circular plots for avifauna. Surveys conducted seasonally provided baseline data characterizing habitat and species relationships and seasonal fluctuations.

88. **Terrestrial Biological Studies for Geysers Unit 21 and 22 Geothermal Power Plants** (Pacific Gas and Electric Company)

Our team conducted the biological research required to meet the California Energy Commission's Application for Certification process for the proposed geothermal plants and transmission line corridors. Our company surveyed for rare plants and special status wildlife, mapped vegetation, and identified and analyzed critical and sensitive habitats. Methods to identify wildlife species occurrence within the study area included ringtail trapping, mammal scent-stations, and raptor time-area counts. The California Wildlife Habitat Relationship Program (WHRP) enabled us to evaluate habitat suitability for sensitive, recreational, and commercial wildlife species. Finally, we assessed impacts from construction and operation of the project on vegetation and wildlife.

89. **IFIM Analysis for Mammoth Pool Hydroelectric Project Modification** (Southern California Edison Company)

BioSystems completed an IFG-4 analysis on portions of the San Joaquin River below Mammoth Pool Dam to ascertain the effects of modified flows on fisheries. In addition, we implemented an instream thermal model developed by USFWS to study the relationship between stream temperature and stream flow in the San Joaquin River. The SCIES model was then used to determine the effectiveness of management alternatives based on manipulating flow.

90. **Bellevue Gold Mining Project** (Environmental Management Services Company)

Our studies for a gold-mining project in the northern Sierra Nevada included a literature review, fish distribution and abundance survey, stream habitat survey, rare plant survey, and wildlife reconnaissance. We analyzed the impacts of project development on fisheries resources, vegetation, and wildlife.

91. **Solano Wind Turbine Raptor Studies** (Pacific Gas and Electric Company)

A comparative survey of raptor use on adjacent developed and undeveloped wind turbine generation sites in Solano County was conducted by BioSystems personnel.

92. **Productivity of Anadromous Salmonids in the Pacific Northwest** (Northwest Power Planning Council)

We characterized the nature and extent of available information on present and potential productivity of anadromous salmonid fish in Oregon, Washington, and Idaho. Descriptions of each data source were computerized and cross-referenced by biological topic, geographic location, sponsoring agency, and standard bibliographic material. The final report also evaluated the usefulness of each type of information in the Northwest Hydropower Assessment, a classification of rivers by their suitability for hydropower development.

93. **Crane Valley Hydroelectric Project** (Pacific Gas and Electric Company)

This 2-year, $1+ million project entailed twenty major research tasks, eleven technical reports, and a summarization of research and recommendations in a regulatory exhibit for submission to the Federal Energy Regulatory Commission. Research addressed the impacts of a complex of hydroelectric facilities located in the California Sierra. Facilities and environmental features studied included a major dam and four smaller diversion dams, a major storage reservoir (active storage in excess of 45,500 acre-feet), two smaller seasonal storage reservoirs and afterbays, three forebays, 14 miles of conduits, and over 20 miles of stream and 30 miles of transmission facilities. BioSystems managed and conducted a complete research program concerning facility impacts on fish, wildlife, botanical resources, water quality, and hydrology. Studies included instream flow requirements for anadromous and warmwater fish using IFIM models; electroshocking fish surveys; fish habitat characterization; instream and lake temperature modeling; integrated analysis of water temperatures throughout the system under various flow releases from the main storage reservoir; benthic invertebrate sampling; water quality sampling for over two dozen parameters at 17 locations; assessment of hydrologic data from 35 gaging stations; sedimentation and sediment transport in Crane Valley watercourses; vegetation habitat mapping of all project features; rare plant and rare wildlife field surveys; exhaustive field surveys for a rare riparian plant and statistical analysis its ecological requirements; field relevé and transect surveys of riparian vegetation and statistical analysis of correlations between streamflow and vegetation structure and composition; characterization of riparian wildlife, raptors, and other sensitive wildlife in the area; and in-depth field studies of mule deer movements along project conduits.

94. **Pit River Bald Eagle Study** (Pacific Gas and Electric Company)

This seven-hundred-thousand dollar, two-year ecological investigation of endangered bald eagles and their prey resources along the Pit River in Northern California formed part of a FERC Exhibit E document prepared by PGandE for the Pit-3,4,5 hydroelectric project. It reports the potential impacts of altering reservoir levels and streamflows to generate hydroelectric power along the river. The Pit River facilities are located in an area that supports the greatest concentration of nesting bald eagles in the state. BioSystems managed a detailed investigation, conducted by the University of California at Davis Fisheries Group, of several resident fish species that were the eagle's primary prey resource, and we conducted two years of field investigations to monitor eagle wintering and breeding activities. BioSystems radio-telemetered bald eagles and followed them as far as British Columbia, radio-telemetered Sacramento sucker populations in the Pit River, characterized human disturbance and public use factors affecting the eagles, evaluated four management approaches proposed by state and federal agencies for an interagency Pit River Bald Eagle Management Plan, and integrated the results of several major concurrent studies,

including IFIM, water quality, water temperature, habitat modeling, and algae studies. Our report is the most comprehensive research ever published on the species.

95. **Calculation of Pacific Northwest Environmental Costs and Benefits of Hydropower Development** (Bonneville Power Administration)

In this ground-breaking economic analysis, BioSystems developed a procedure for estimating a regional environmental cost function for hydroelectric development and used it to estimate costs for hydro impacts on fish and fishing, hunting, riparian habitat, and free- flowing streams. This assignment involved identifying and quantifying environmental products significantly at risk from hydro development in the Pacific Northwest; analyzing and categorizing the kinds of development associated with the full range of regional hydro development, from small run-of-the-river to large dams; developing indices to relate the impacts of various hydro project elements to regional products; and using economic techniques to quantify the value of these impacts. BioSystems also assisted in BPA's public involvement process to review our work.

96. **Long Term Intertie Development and Use -Indirect Impacts Assessment** (Bonneville Power Administration)

This report presents our region-wide cumulative assessment of high voltage transmission policy and intertie capacity. It relates the effects of 16 alternative combinations of intertie capacity and policy to changes in electric power plant operation and new plant construction stimulated by the various combinations. We used BPA's input data to calculate the magnitude, significance, and distribution of these changes in power plant operation and construction for three regions: the Pacific Northwest, California, and the Inland Southwest. Then we conducted environmental analyses to quantify impacts on air and water quality, fish, wildlife, fuel use, and electric power rates. Impact analyses took account of effects at the generating plants, regional and cumulative effects, and fuel cycle impacts in regions and places supplying, processing, and transporting fuels to the power plants. A number of sensitivity cases were analyzed (e.g., high and low power sales on the intertie, pricing options, and power sale contract options): including all study years and scenarios, over 30,000 impact values were calculated, interpreted, organized, and summarized.

97. **Tailwater Ecology Below Dams: A Literature Compilation** (Bureau of Reclamation)

BioSystems compiled and summarized about 850 pieces of literature relating to research on the ecology of dam tailwaters for seven Bureau of Reclamation regions covering all 17 western states. The compilation included effects of impoundments on stream physical- chemical parameters, water quality, flow regimes, and biology (including fish, invertebrates, algae, aquatic weeds, and plankton). Major rivers affected included the Missouri, Colorado, and Columbia; altogether research was compiled for approximately 170 tailwater areas on over 100 creeks and rivers.

98. **Big Creek Expansion Project (BiCEP)** (Southern California Edison Company)

In the BiCEP project, we are studying the impact of hydroelectric facilities on cold and warm water fish species in tailwater reaches of Sierran streams. Our analysis includes assessment of the effects of spills and thermal stress on the population structure, abundance, and distribution of fishes. The field-intensive studies are designed to provide baseline data on present operations and possible mitigation measures for proposed changes in operations. The studies include habitat mapping of instream and riparian areas, IFIM assessment, temperature modeling and fish population assessment. BioSystems has developed a methodology called SCIES for assessing the value of stream and riparian areas to fish and wildlife. The

SCIES application combined with the IFIM, temperature model, and fish population data will be used to develop a numerical scoring system (from 0-100) to represent the relative quality of stream resources under different management policies.

99. **Chinook Salmon Biophysical-Economic Model for the Sacramento River Basin** (NOAA-National Marine Fisheries Service)

This study uses our own flow-based chinook salmon population model to estimate the economic value of in-river flows to the fishery. The study's objective is to evaluate the effect on in-river fisheries values of time- and location-specific, out-of-basin diversions. To develop the model, we searched extensively for information relating to chinook salmon life history, production, instream flow requirements and habitat conditions, and the relationships between basin hydrology, water management and productivity of chinook salmon in the Sacramento Basin. The biophysical model will simulate production of salmon under different flow scenarios and will provide input to the economic model being developed by Phil Meyer.

100. **Inventory of Kit Fox and Their Dens along Tucson Aqueduct** (U.S. Bureau of Reclamation)

An intensive survey for kit fox dens was conducted along the entire Tucson Aqueduct (Phase B) right--of-way in areas of suitable kit fox habitat to determine the number of kit fox potentially affected by the proposed construction. Project activities included comprehensive literature review and interviews, night spotlighting, and the development of an index from data on active dens to estimate the number of kit fox affected by the proposed construction. Finally, mitigation measures were described for the construction of the aqueduct.

101. **Bird Monitoring Study for Proposed Windfarm Development** (Howden Windparks, Inc. Flowind Corp.)

BioSystems personnel monitored waterfowl and raptor populations to evaluate potential impacts from windfarm development near Suisun Marsh. The study characterized waterfowl and raptor activity and use patterns before and after construction to determine whether significant differences occur after windfarm development. We also assessed the extent of direct mortality to birds from the wind turbines.

102. **Inventory of San Joaquin Kit Fox and Their Dens along Proposed Canal and Pipe Alignments** (Contra Costa County Water District)

To evaluate the potential for direct and indirect impacts on San Joaquin kit fox of construction of the canal and pipeline, BioSystems determined the presence and distribution of kit fox and habitat suitable for supporting this species along the proposed routes. Methods included literature review, daytime den surveys, and night spotlighting surveys. In addition, a general wildlife survey was conducted along the proposed routes.

103. **Riparian Vegetation in the Haas-Kings Project Area** (Pacific Gas and Electric Company)

BioSystems' Botanists evaluated the potential effects of stream diversions associated with hydroelectric improvements proposed for PGandE's Haas-Kings River Project. Located in Fresno County, the Haas-Kings Project combines normal hydroelectric generation facilities with a large pumped storage system linking Wishon and Courtright Reservoirs. BioSystems sampled 60 transects and over 100 stand surveys to characterize riparian vegetation in the lower reaches of the Project area. Data analysis, utilizing univariate and multivariate methods, combined with hydrologic modeling demonstrated levels of impact under alternate Project configurations.

104. **Potential Ecological Effects of Reduced Instreamflow, Lower American River, Sacramento, California** (East Bay Municipal Utilities District)

Riparian vegetation along the 21-mile American River Parkway through metropolitan Sacramento was evaluated with regard to a proposal to divert over 200,000 acre-feet of water annually into the Folsom south Canal. BioSystems characterized vegetation along six representative reaches of the river. Potential effects of changed hydrology upon riparian vegetation and associated wildlife was evaluated. Information developed and provided by BioSystems was at the request of the State Water Resources Control Board.

105. **Demographic Characteristics of Dominant California Riparian Plants** (Pacific Gas and Electric Company)

Basic research on life-history attributes of important riparian trees and shrubs was conducted by BioSystems botanists during 1985 and 1986. Specific sampling sites were chosen on both the western and eastern slope of the Sierra Nevada. Data on age structure of populations was collected. Seedling recruitment patterns were studied in relation to riparian zonation and substrate factors. Dynamics of vegetative versus seed reproduction was studies for sprouting species such as cottonwoods and willows.

106. **Empirical Modeling of Ecological Effects of Stream Diversions, Sierra Nevada** (Pacific Gas and Electric)

BioSystems standardized sampling protocols used for evaluation of riparian vegetation under studies funded by PGandE's Riparian Ecology Project. Data collected from several different PGandE studies were combined. The data set, representing the single largest body of data on California riparian vegetation, will be utilized for empirical verification of simulation models under development by PGandE.

107. **Fish Utilization of Artificial Rocky Reefs in Shaver Lake** (Southern California Edison Company)

BioSystems is evaluating the effectiveness of habitat enhancement to improve the Shaver Lake fishery in the Sierra Nevada, by comparing littoral areas with no cover to both natural and artificial reefs. We are determining the effects of the reefs on all life stages, including spawning and rearing. This project involves documenting use of fish habitat by quantitative visual surveys using scuba and snorkeling gear and hydroacoustic and underwater video equipment. This study includes electroshocking, gill netting, and habitat mapping.

108. **Ecology of Bald Eagles in Central Arizona** (Bureau of Reclamation)

BioSystems is conducting a $1.4 million, 4-year study in central Arizona on bald eagles and their prey resource. This project is an in-depth ecological investigation of this endangered species in relation to proposed and existing water projects in Arizona. The bald eagle work includes studies on reproductive success, foraging and feeding behavior, habitat use, and migration. Extensive reservoir and riverine fisheries work is being conducted to determine the effects of water projects on fish, the eagle's primary prey source. Tasks include mapping aquatic habitats and spawning areas in reservoirs, rivers, and streams; determining the relative importance of spawning in tributaries to lake and river fish populations; assessing changes in the total area of the littoral zone and the resulting effect on fish populations; water quality studies; determining sources of the carrion; studying the seasonal distribution of reservoir and river fishes; conducting quantitative surveys of fish spawning chronology using snorkeling, scuba and hydroacoustics gear.

109. **Roving Creel Survey - Lake Havasu** (California Department of Fish and Game)

BioSystems is conducting a two-year roving creel survey of Lake Havasu in San Bernardino County, California. We are documenting public use of the fishery resource, determining composition of catch, number of people using the reservoir, fishing success, health of the fish population, and collecting scales for age-growth analysis.

110. **Biological Assessment of Shiloh Ranch** (Shiloh Associates)

BioSystems personnel conducted a baseline biological inventory of a 2700-acre parcel northeast of Santa Rosa in Sonoma County, California. Vegetation and wildlife habitats were characterized and mapped, and a field reconnaissance was carried out for rare and endangered plants and special-status wildlife species. A mitigation plan was developed to resolve project conflicts with two rare vernal pool plants and loss of habitat for several wildlife species.

111. **Botanical Resources of the Proposed Geothermal Public Power Line** (Wirth Environmental Services)

BioSystems provided quality-control and field assistance in the floristic survey of a 70-mile-long transmission line corridor in Sonoma, Lake, and Colusa counties, California. Vegetation types, sensitive habitats, and sensitive plant species were also surveyed along the proposed route. Sensitive habitat types traversed by the proposed line include serpentine barrens and serpentine chaparral, vernal pools, and native bunchgrass stands. Botanical features of significance were evaluated for their susceptibility to disturbance and their potential for mitigation.

112. **Status Survey of Three Plants Endemic to the San Joaquin Valley** (U.S. Fish and Wildlife Service)

A comprehensive status survey was conducted for three annual plant species -- *Caulanthus californicus, Eremalche kernensis,* and *Eriastrum hooveri* -- which have sustained significant habitat loss primarily due to agricultural development in California's San Joaquin Valley. BioSystems botanists determined the historical distribution for each of the study plants and conducted systematic field surveys of known sites and areas of potential habitat. Recommendations were made concerning the listing of these species under the federal Endangered Species Act.

113. **Status Survey of the Grass Tribe Orcuttieae** (U.S. Fish and Wildlife Service)

BioSystems botanists conducted a comprehensive, two-year status survey of seven rare and endangered vernal pool annuals in the Central Valley of California. Included in the survey were six members of the unique grass tribe Orcuttieae and *Chamaesyce hooveri*, another Central Valley endemic which often occurs with Orcuttieae species as a result of similar habitat requirements. The historical range of each species was determined, and extensive field surveys were conducted to document the current status of known populations and search for previously undocumented populations. Recommendations were made concerning the listing of these species under the federal Endangered Species Act.

114. **Sensitive Plant Survey of the California-Oregon Transmission Project** (Transmission Agency of Northern California)

As part of the required environmental studies leading to the preparation of a combined EIR/EIS, BioSystems botanists are conducting a two-year field survey of rare, threatened, and endangered plant species along the preferred route, which extends some 340 miles from southern Oregon to central California. The route traverses several vernal pool areas and other habitat types with potential to support sensitive plant populations.

115. **Biological Assessment of Proposed Improvements to the Cloverdale-Geysers Road** (Stone and Webster Engineering Corporation)

Related to road improvements proposed by the Central California Power Agency and the County of Sonoma, a baseline biological inventory was conducted along an eight-mile stretch of the Cloverdale-Geysers Road. BioSystems botanists and wildlife biologists evaluated potential environmental impacts and recommended appropriate mitigation measures.

116. **Avenal Prison Rare Plant Survey** (Pacific Gas and Electric Company)

BioSystems botanists conducted rare plant surveys in conjunction with construction of the new Avenal State Prison in Kings County, California. Associated with construction of the prison, we surveyed a 4.5 mile-long utility corridor the traversed native habitat in the Kettleman Hills.

Appendix B.
Field Data Form and Specifications

RIPARIAN VEGETATION TRANSECT DATA

Stream _____

ID No. 1 2 REACH 3 TRANSECT 4 5

CARD TYPE 6 1 CON'D 7

DATE 8 9 10 11 12 13 (M M D D Y Y)

DISTANCE FROM DIVERSION (meters) 14 15 16 17

ELEVATION (feet) 18 19 20 21

RECORDER (initials) 22 23 24

ASPECT (degree) 25 26 27

VALLEY SLOPE (degree) 28 29 30 31

SUBSTRATE CODE 32

VEG. CODE 33

IMPACT CODE 34

FLOOD CODE 35

FLUVIAL LOCATION CODE 36

TRANSECT LENGTH 37 38 39

CARD TYPE 6 2 CHANNEL WIDTH

1 START	1 STOP	2 START	2 STOP	3 START	3 STOP	4 START	4 STOP
8 9 10	11 12 13	14 15 16	17 18 19	20 21 22	23 24 25	26 27 28	29 30 31

CARD TYPE 6 3 CHANNEL ELEVATION AT THALWEG

1	2	3	4
8 9 10	11 12 13	14 15 16	17 18 19

WATER DEPTH

1	2	3	4
20 21 22	23 24 25	26 27 28	29 30 31

CARD TYPE 6 4 PROFILE (Fixed stations)

A DIST	A ELEV	B DIST	B ELEV	C DIST	C ELEV	D DIST	D ELEV	E DIST	E ELEV
8 9 10	11 12 13	14 15 16	17 18 19	20 21 22	23 24 25	26 27 28	29 30 31	32 33 34	35 36 37

F DIST	F ELEV	G DIST	G ELEV	H DIST	H ELEV	I DIST	I ELEV	J DIST	J ELEV
38 39 40	41 42 43	44 45 46	47 48 49	50 51 52	53 54 55	56 57 58	59 60 61	62 63 64	65 66 67

CARD TYPE 6 4 1 PROFILE EXTRAS

DIST	ELEV	DIST	ELEV	DIST	ELEV	DIST	ELEV	DIST	ELEV
8 9 10	11 12 13	14 15 16	17 18 19	20 21 22	23 24 25	26 27 28	29 30 31	32 33 34	35 36 37

CARD TYPE 6 5

SPECIES	DBH	DIST	G	DELT DBH	TRANSECT DIST	S	DBH	DIST	G	DBH	DIST	G	DELT WIDTH
8 9 10 11 12 13	14 15 16	17 18 19	20	21 22 23	24 25 26	27	28 29 30	31 32 33	34	35 36 37	38 39 40	41	42 43

LINE INTERCEPT _____

6	6	7	SPECIES 8	9	10	11	12	13	S 14	START 15	16	17	STOP 18	19	20	S 21	START 22	23	24	STOP 25	26	27	S 28	START 29	30	31	STOP 32	33	34	S 35	START 36	37	38	STOP 39	40	41	S 42	START 43	44	45	STOP 46	47	48

NOTES: _____

_____

_____

PHOTOS ROLL NO. _____ FRAMES _____

HERB QUADRATS

ID | 1 | 2 |

REACH | 3 | 4 | 5 |

No.			S	SPECIES						COVER	SPECIES						COVER	SPECIES						COVER	SPECIES						COVER
7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41

Specifications for Riparian Vegetation Transect Data Form

Column	Variable	Specifications
All Cards		
0	Stream Name	Self explanatory for visual inspection & data management.
1-2	ID NO.	Stream Identification Number. To be assigned sequentially.
3	Reach	To be assigned sequentially.
4-5	Transect	Transect Number.
	——— CARD TYPE 1 ———	
6-7	Card Type/Cont'd.	
8-13	Date	Month, Day, Year
14-17	Distance from Diversion	Meters
18-21	Transect Elevation	Feet above sea level
22-24	Recorder	Initials of Data Recorder
25-27	Aspect	Aspect of Stream - in transect section (degrees, from compass)
28-29	Valley Slope-Left	As facing downstream - in degrees
30-31	Valley Slope - Right	As facing downstream - in degrees
32	Substrate Code	**1** = bedrock **2** = lg boulders (<1m diameters) **3** = sm boulders (>2dm diameters) **4** = cobbles (>2dm<2cm) **5** = gravel (>2cm<2mm) **6** = sand & silt (<2mm) **7** = woody debris Dominant substrate in transect location
33	Vegetation Code	Vegetation of upland site at transect location **1** = conifer forest **2** = oak woodland/savannah **3** = chaparral **4** = meadow **5** = annual grassland **6** = granite dome community

34	Impact Code	Land Use Impact Code 1=low 2=moderate 3=severe
35	Flood Code	Estimate of recent flooding damage 1=low 2=moderate 3=severe
36	Fluvial Location Code	1=point bar 2=inside meander 3=pool 4=riffle
37-39	Transect Length	in decimeters

———— CARD TYPE 2 ————

	Channel Width	Start of intercepted distance of channel (s) in decimeters
8-10 14-16 20-22 26-28		Start intervals
11-13 17-19 23-25 29-31		Stop intervals
37-39		Thalweg distance in decimeters

———— CARD TYPE 3 ————

8-10 11-13	Channel Elevation(s) at Thalweg	In feet and tenths below origin (FORTRAN format F 3.1).
14-16 17-19		
20-22 23-25 26-28 29-31	Water Depth	In feet and tenths below origin (FORTRAN format F 3.1).

CARD TYPE 4

8-10	A Dist	Profile Station A: Left side stream (facing down) at edge of riparian zone at zero point on tape.
11-13	A Elev	Profile Station A: Elevation in feet and tenths of transect origin.
14-16	B Dist	Profile Station B: -distance along transect in dm.
17-19	B Elev	Profile Station B: Elevation in feet and tenths
20-22	C Dist	Profile Station C: -distance along transect in dm.
23-25	C Elev	Profile Station C: Elevation in feet and tenths
26-28	D Dist	Profile Station D: -distance along transect in dm.
29-31	D Elev	Profile Station D: Elevation in feet and tenths
32-34	E Dist	Profile Station E: Edge of stream at date sampled -distance along transect in dm.
35-37	E Elev	Profile Station E: Elevation in feet and tenths
38-40	F Dist	Profile Station F: Edge of stream on bank opposite transect origin at date sampled -distance along transect in dm.
41-43	F Elev	Profile Station F: Elevation in feet and tenths
44-46	G Dist	Profile Station G: -distance along transect in dm.
47-49	G Elev	Profile Station G: Elevation in feet and tenths
50-52	H Dist	Profile Station H: -distance along transect in dm.

53-55	H Elev	Profile Station H: Elevation in feet and tenths
56-58	I Dist	Profile Station I: -distance along transect in dm.
59-61	I Elev	Profile Station I: Elevation in feet and tenths
62-64	J Dist	Profile Station J: Edge of riparian zone on side opposite transect origin -distance along transect in dm.
65-67	J Elev	Profile Station J: Elevation in feet & tenths
7	cont'd	Extra profile stations as needed

CARD TYPE 5

7 cont'd		
8-13	Species	Species Acronym Code (according to USDA 1982 Standard) 6-digit code, left justified
14-16 21-23 28-30 35-37	DBH	Diameter at breast height (1.4m) above ground in cm.
17-19 24-26 31-33 38-40	Distance	Rooted distance along transect (dm)
20 27 34 41	Substrate Code	Rooted substrate of each stem **1** = bedrock **2** = lg boulders (>1m diameter) **3** = sm boulders (>2dm diameters) **4** = cobbles (<2dm>2cm) **5** = gravel (<2cm>2mm) **6** = sand & silt (<2mm) **7** = woody debris
42-43	Belt Width	Strip transect belt width - in meters

CARD TYPE 6

7 cont'd		
8-13	Species	Species Acronym Code (according to USDA 1982 Standard) 6 digit code left justified
14 21 28 35 42	Substrate Code	Rooted substrate of intercepted individual **1** = bedrock **2** = lg boulders (>1m diameter) **3** = sm boulders (>2dm diameters) **4** = cobbles (<2dm>2cm) **5** = gravel (<2cm>2mm) **6** = sand & silt (<2mm) **7** = woody debris
15-17	Start	Start of intercepted distance of woody plant 22-24(distance along transect in decimeters)
29-31 36-38 43-45		
18-20	Stop	Stop of intercepted distance of woody plant 25-27(distance along transect in decimeters) 32-34
39-41 46-48		

CARD TYPE 7

7 cont'd		
8-13	Additional Species	Species Acronym Code (according to USDA Standard 16-21) 6 digit code, left justified 24-29
32-37 40-45		
14-15	Percent Cover	Estimated percent cover in reach
22-23 30-31 38-39 46-47		

CARD TYPE 8

7 cont'd

8-9	Quadrat Number	
10	Substrate Code	Dominant substrate in 1X1 meter quadrat **1** = bedrock **2** = lg boulders (>1m diameter) **3** = sm boulders (>2dm diameters) **4** = cobbles (<2dm>2cm) **5** = gravel (<2cm>2mm) **6** = sand & silt (<2mm) **7** = woody debris
11-16 19-24 27-32 35-40	Species	Species Acronym Code (according to USDA 1982 Standard) 6 digit code, left justified
17-18 25-26 33-34 41-43	Cover	Estimated cover in a 1x1 meter quadrat (in percent) Ocular estimate for species with >5% cover