



# abstracts

FIRST CONFERENCE ON SCIENTIFIC RESEARCH IN THE NATIONAL PARKS

9-13 NOVEMBER 1976  
NEW ORLEANS, LOUISIANA

SPONSORED BY  
AMERICAN INSTITUTE OF  
BIOLOGICAL SCIENCES  
AND  
NATIONAL PARK SERVICE  
UNITED STATES DEPARTMENT  
OF THE INTERIOR



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First Conference on Scientific Research  
in the National Parks

PROGRAM CHANGES AND ADDITIONS

CONFERENCE SOCIAL Monday evening, November 8 from 7:00-9:00 p.m. has been changed from the Imperial Salon to the *Presidential Salon* on the Upper Mezzanine Floor.

PRESS ROOM moved from Meeting Room #12 to *Meeting Room #6* on the Second Floor.

Due to insufficient response, the NEW ORLEANS SIGHTSEEING TOURS (ST Nos. 1,2,3,4) have been cancelled. Refunds for advance reservations may be obtained from Carol Chisholm or Lorraine Tucker of the AIBS staff in the *Registration Area* or *Conference Headquarters Office* during the Conference period.

\* \* \* \* \*

AQUATIC BIOLOGY SESSION 2.

PAPER 106. scheduled at 3:30 p.m. will be presented in Aquatic Biology Session 3. on Thursday afternoon at 3:30 p.m. PAPER 106. will replace PAPER 214. which has been cancelled.

PAPER 107.	will be presented at 3:30 p.m.	PAPER 110.	will be presented at 4:30 p.m.
PAPER 108.	" " " " 3:50 p.m.	PAPER 111.	" " " " 4:50 p.m.
PAPER 109.	" " " " 4:10 p.m.	PAPER 112.	" " " " 5:10 p.m.

AQUATIC BIOLOGY SESSION 3. \_\_\_\_\_

PAPER 214. scheduled at 3:30 p.m. has been cancelled and replaced by PAPER 106.

GEOLOGY SESSION 1. \_\_\_\_\_

PAPER 22. scheduled at 1:17 p.m. has been cancelled. PAPERS 21. and 23.-29. will be presented at the times listed in the *Conference Program*.

TERRESTRIAL BIOLOGY, BOTANY SESSION 1. \_\_\_\_\_

PAPER 49. scheduled at 1:20 p.m. will be presented in Terrestrial Biology, Resources Management Session 4. on Wednesday afternoon at 1:20 p.m. as PAPER 122a. PAPER 244. will be presented as PAPER 49.

PAPER 50. scheduled at 1:40 p.m. will be presented in Terrestrial Biology, Resources Management Session 4. on Wednesday afternoon at 1:40 p.m. as PAPER 122b. PAPER 245. will be presented as PAPER 50.

PAPER 59. scheduled at 5:10 p.m. has been cancelled.

TERRESTRIAL BIOLOGY, RESOURCES MANAGEMENT SESSION 4. \_\_\_\_\_

PAPER 126. scheduled at 2:20 p.m. will be presented in Terrestrial Biology, Resources Management Session 6. at 4:30 p.m. as PAPER 244.

PAPER 127. scheduled at 2:40 p.m. will be presented in Terrestrial Biology, Resources Management Session 6. at 4:50 p.m. as PAPER 245.

PAPER 122. will be presented at 1:00 p.m.  
PAPER 122a. (formerly 49.) will be presented at 1:20 p.m.  
PAPER 122b. (formerly 50.) will be presented at 1:40 p.m.  
PAPER 123. will be presented at 2:00 p.m.  
PAPER 124. will be presented at 2:20 p.m.  
PAPER 125. will be presented at 2:40 p.m.

PAPERS 128-133. will be presented at the times listed in the Conference Program.

**TERRESTRIAL BIOLOGY, RESOURCES MANAGEMENT SESSION 5.**

PAPER 140. has been cancelled. PAPER 142. will be presented at 3:30 p.m.  
PAPER 141. has been cancelled. PAPER 143. will be presented at 3:50 p.m.  
PAPER 144. will be presented at 4:10 p.m.

**TERRESTRIAL BIOLOGY, BOTANY SESSION 2.**

PAPER ADDITION:

3:50 PAPER 151a. KRUPA, S. University of Minnesota, St. Paul. Air pollution-Vegetation effects studies in the National Park system.

PAPER 152. will be presented at 4:10 p.m. PAPER 154. will be presented at 4:50 p.m.  
PAPER 153. will be presented at 4:30 p.m. PAPER 155. will be presented at 5:10 p.m.

**TERRESTRIAL BIOLOGY, BOTANY SESSION 3.**

TITLE CHANGE:

3:50 PAPER 258. Factors associated with failure of Giant Sequoia. Part I. Pathological aspects.

PAPER ADDITION:

4:10 PAPER 258a. TILLES, D.A., D.D. PIIRTO, C.T. DAVID, J.R. PARMETER, JR., W.W. WILCOX and D.L. WOOD. University of California, Berkeley. Factors associated with failure of Giant Sequoia. Part II. Entomological aspects.

PAPER 259. will be presented at 4:30 p.m. PAPER 261. will be presented at 5:10 p.m.  
PAPER 260. will be presented at 4:50 p.m.

**TERRESTRIAL BIOLOGY, ZOOLOGY SESSION 6.**

PAPER ADDITION:

5:30 PAPER 272a. SWIFT, DAVID M. Colorado State University, Fort Collins. Application of a ruminant energetics model to a study of elk winter range carrying capacity.

BRANIFF PLACE CHECK-OUT

TIME IS 1:00 P.M.

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I. ANTHROPOLOGY

YOUR MOVE! THE CHANCE AND CHOICE OF SCIENCE IN THE NATIONAL PARKS

EULER, ROBERT C.

Grand Canyon National Park  
Grand Canyon, Arizona 86023

NO ABSTRACT SUBMITTED

## A CRITIQUE OF NATIONAL PARK SERVICE ARCHEOLOGY

LISTER, R. H.

Reviews are presented of the author's experiences in conducting archeological investigations in National Park Service areas (a) as a University faculty member working under contract with the Park Service and (b) as a Park Service employee directing an archeological program in a Park.

The advantages and disadvantages of both methods of accomplishing archeological research in the National Parks are considered and evaluated. Restraints imposed upon certain aspects of archeological programs by the nature of the National Park Service management system are believed to impede productive research.

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NATIONAL PARK SERVICE ARCHEOLOGY: PAST, PRESENT AND FUTURE

\*LOGAN, WILFRED D. AND \*\*CALABRESE, F. A.

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NO ABSTRACT SUBMITTED

MONTANE COCHISE CULTURE SITES IN CORONADO NATIONAL MEMORIAL

STEWART, YVONNE

A recent survey of 5000 acres in and adjacent to Coronado National Memorial revealed several Cochise Culture sites, primarily of the Chiricahua Stage, situated at higher altitudes than have been surveyed before. This paper discusses the relationship of these sites to other known Cochise Culture sites in the San Pedro Valley in terms of environmental utilization, site function, settlement pattern and social organization.

Sites primarily are located in areas adjacent to permanent water resources and suitable for direct environmental exploitation. Artifact types and areal distribution indicate two major functional site types: base camps and work camps. The settlement pattern consists of a series of mobile encampments. Site size and lithic density indicate less intensive utilization of areas at this altitude than of areas at slightly lower altitudes reported from nearby surveys. Social organization is probably that of small bands, which disperse for various work camp activities. There is no evidence of a gathering of several bands.

It is hypothesized that either the southeastern flanks of the Huachucas constituted a fringe area for the Chiricahua Stage of the Cochise Culture or that there was little intensive use of the environment at these altitudes during that temporal period.

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NAVAJO ARCHEOLOGY IN CANYON DEL MUERTO: THE HISTORIC STUDY OF THE  
MODERN INHABITANTS OF CANYON DE CHELLY NATIONAL MONUMENT, ARIZONA

MAGERS, PAMELA C.

Canyon de Chelly National Monument is unusual in that the Navajo Indians who entered the area during the 18th century still occupy the monument land and carry on the 20th century version of their traditional culture. The Canyon del Muerto Survey conducted by the Western Archeological Center during the summers of 1975 and 1976 provided data on Navajo settlement and utilization of the area from about 1750 to the present. This allows a diachronic discussion of the changing relationships of the Navajo with their natural and social environments. Canyon de Chelly is the traditional "fortress" of the Navajo. Prior to the Fort Sumner incarceration of the Navajo (1864-1868) exploitation and occupation of the canyon were constrained by defensive requirements. After Fort Sumner, changing economic considerations and the developing transportation system led to increasing dependence upon Anglo products. This dependence has produced a shift in settlement location and community patterning in order to facilitate access first to the ration center at Fort Defiance (1870's), then to the trading posts at the head and mouth of the canyon (1880's-1920's), and now to the stores and opportunities for wage work available in the modern town of Chinle at the mouth of the canyon.

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NEW INTERPRETATION OF CANYON DE CHELLY PREHISTORY:  
SUMMARY OF THE ANTELOPE HOUSE PROJECT

MORRIS, DON P.

The findings of the Antelope House Project are reviewed in terms of prehistoric social organization, subsistence and technology, and the effects of the changing prehistoric environment on these aspects of culture. Attribute analysis of seven artifact categories supports a model of two contemporaneous social groups at the site, each flanking a circular central plaza. Consideration of the architecture of other canyon sites indicates this is a common pattern. Intensive study demonstrates the significance of wild foods in the diet, especially cactus and beeweed. Beans are uncommon, and cottonseed is consumed instead. Deer and domesticated turkeys are important meats, although turkeys are kept primarily for feathers. Canyon de Chelly is a major center for the production of feather blankets and cotton textiles, based in part on the occurrence at Antelope House of half of all the cotton textiles known from the Southwest. Exploitation of the yucca is shown to be basic to textile production. Independently proposed drought periods correlate with building episodes at the site, abandonment of nearby plateau sites, and with fluctuations in types of vegetal refuse. Area abandonment results from a sequence of drought, increased rainfall and erosion, and more severe drought accompanied by cooling trends from AD 1140 to 1280.

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PREHISTORIC SETTLEMENT PATTERNS IN CANYON DE CHELLY NATIONAL  
MONUMENT

McDONALD, JAMES A.

The Canyon del Muerto Survey, an archeological survey within Canyon de Chelly National Monument, Arizona, has documented changes through time in prehistoric settlement patterns in the monument. These changes reflect responses to variation in the availability of certain wild foods resulting from fluctuations in local climatic conditions.

The survey area can be divided into two major topographic units: Canyon del Muerto and the Defiance Plateau, into which the canyon is cut. Archeological sites of the Anasazi culture are found in both units. On the plateau, Anasazi sites show a strong correlation with stands of pinyon and juniper, and appear to be pinyon nut collection stations. Almost all Anasazi plateau sites belong to the late Pueblo II-early Pueblo III and Basketmaker III periods of the Anasazi cultural sequence. The former period has been shown to have been a time of favorable climatic conditions, in the form of above-average rainfall. It is argued that the Anasazi took advantage of this favorable climatic interval by incorporating greater proportions of pinyon nuts in their diet. It is also argued that the Basketmaker III period was a time of favorable climate and heavy exploitation of the pinyon.

The implications of these arguments are discussed, and it is concluded that the role of wild foods in Anasazi subsistence has generally been underestimated.

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ATLATL CAVE; ARCHAIC - BASKETMAKER II INVESTIGATIONS IN  
CHACO CANYON NATIONAL MONUMENT.

MATHEWS, T. W., NELLER, E. H.

Search for the beginnings of agriculture in the Chaco in Archaic and Basketmaker II sites where these horizons are little known has resulted in the identification of 95 sites, out of more than 2000 recorded. Five have been sampled. Two seasons of excavation in one, Atlatl Cave, and nearby dunes, have yielded extensive collections of biotic and cultural materials. Some biotic forms salvaged are no longer found in the area.

Excavations in the shelter indicate two concentrations for the cultural and biotic remains associated with numerous hearths. Deposits are shallow, 25 to 60 cm. Some differences in content were noted in the concentrations. Bison and Archaic projectile points occur in one; part of an atlatl and a yucca sandal in the other. Corn and squash remains were found in both. Woodrat nests and amberat deposits were present in both concentrations and yielded twigs, needles and cones of pinyon (Pinus edulis) and twigs and cones of Douglas fir (Pseudotsuga taxifolia). Neither occur locally today.

Two series of test trenches in dunes fronting the cave mouth yielded Archaic lithic materials, a hearth and a basin metate from the top 20 cm. suggesting special use areas. Test pits to 2.3 m. were sterile.

Dune formation has been suggested circa 4500 years ago and the typology of dune and shelter artifact assemblages indicate San Jose phase and later. The floral and faunal collections are offering opportunities to explore the ecological context of these sites as they changed through time, and provide a chance to assess some environmental factors affecting prehistoric man in the Chaco.

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STRANGE BEDFELLOWS? :TANGENT POINTS OF IN-PARK CULTURAL AND NATURAL RESOURCES RESEARCH.

KELLY, ROGER E.

Both archaeologists and natural scientists need to be aware of four potentially significant points of mutual concern; the impact on each other's resource base by contrasting specialists, the utilization of data by counterpart disciplines, the possible enclaved nature of resources within parks for future research, and differing management attitudes toward differing resources. Examples from NPS Western Region areas will be highlighted to indicate points of this paper.

In research or management actions dealing with park flora, botanists and others may not realize the impacts upon archaeological materials of both historic and prehistoric periods of eradication of exotics, re-introduction of native species, or similar actions. Changes in park plant communities - of interest to some botanists - may be documented in archaeological work but archaeologists may not be aware of rare or endangered species within project areas. Effects of controlled burns upon surficial or subsurface cultural materials have not been sufficiently addressed by archaeologists or fire management specialists.

Park fauna - domestic, feral, or wild - often are subjects for necessary research and actions which may also impact cultural resources. Co-ordination of actions resulting from animal management studies should be done to determine impacts on cultural resources, if any. Although many archaeologists readily use data from other sciences, sometimes workers tend to operate in a professional vacuum and do not recognize the accessibility of studies and accomplished researchers present in many parks. Non-archaeological project leaders may not be aware of cultural data at hand which relate to environmental change, present or absence of species, or similar aspects of park environment.

In certain areas of the country, both cultural and natural resources within parks may comprise relic or enclaved associations in future decades. Both enlightened management and wise scientific stewardship of resources will be increasingly important to all students of phenomena within NPS areas, present and future. Managers and professional researchers need to build upon the 1975 NPS Management Policies.

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## STEPS AND TRAILS IN THE GLEN CANYON AREA

PATTISON, N.

The area in the Upper Colorado River Basin, now inundated by Lake Powell, was first occupied by the Kayenta Anasazi who farmed the rich alluvial terraces of the side canyons of Glen Canyon. After an apparent hiatus Navajo herders brought in their sheep, early settlers grazed cattle, and miners worked the Colorado River sand bars for gold. The extensive system of "moqui steps" (prehistoric hand and toe holds) and trails developed by these Anasazi farmers to facilitate ascent and descent to the more easily traversed Carmel and Kayenta platforms was adopted and utilized by the incoming ranchers, miners, and Navajos. These interesting hand and toe holds, and the trail system, with its implications, are discussed and illustrated.

Prior to the flooding of Lake Powell and the establishment of the Glen Canyon National Recreation Area an ambitious salvage archeology project was undertaken by the University of Utah and the Museum of Northern Arizona. The entire area was carefully surveyed for archeological and historical sites. Many instances of prehistoric hand and toe holds, Navajo stock trails, miners' carefully picked steps, and missionaries' and explorers' pathways were found and recorded but no complete inventory or monograph has been published. During the mapping of shoreline surface materials for the NSF-RANN Lake Powell Research Project the aforementioned steps and trails were carefully noted, including some never before recorded. It became apparent that they were all part of an intricate trail system which represented a cultural interaction involving such factors as the use of Colorado River water, alluvial farming terraces, chipping sites, storage areas, grazing areas, and gold with the seemingly inaccessible highlands above the outer gorge of the river. These interactions are the subject of a future monograph.

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ARCHEOLOGICAL "OVERVIEWS" OF JOSHUA TREE NATIONAL MONUMENT

KING, T. F.\*, HICKMAN, P. P.\*\*

After years of archeological research in the National Parks, it is now necessary to conduct "overview studies" to ascertain what has been done and what sorts of research should be pursued in the future.

At Joshua Tree National Monument in the California Desert, archeological fieldwork has been haphazard, biased toward an exclusive concern with prehistory, lacking in coordination and research direction, and productive largely of data that cannot now be very systematically used. Historic resources have been viewed as the exclusive province of the historian and historical architect; their anthropological potential has characteristically been missed.

The sample of prehistoric and historic resources represented at the Monument holds promise for the study of social and economic adaptations to marginal environments and to environmental change, of acculturation and culture-contact, and of social responses to the passing of the American frontier. Identifying the potential of the Monument's resources has required intensive study of historical documents and general sources; it has been difficult to make much use of the archeological and historical studies carried out within, or for, the Monument itself in the past.

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## KEYS' RANCH: THE ANTHROPOLOGY OF AN HISTORIC RANCH

HICKMAN, P.P.

Keys' Ranch, a ranch site in Joshua Tree National Monument, was established in about 1910 and abandoned in 1969. It has been described as a "magnificent junkpile" because its owner, William Keys, had a propensity to "glean" tools, equipment, and other material from abandoned mines and mining communities in the area and stockpile such material at the Ranch. The material is still there, in highly organized heaps and piles.

During the course of its history, Keys' Ranch gradually declined from the status of a rather important center for interaction among miners, freighters, prospectors, and others, to that of an isolated single-family residence with tourist-attraction pretensions. At the same time, a nearby settlement, Twentynine Palms, grew from initial parity with Keys' Ranch to the status of a major community. This phenomenon is characteristic of the passing frontier: interaction networks become increasingly "focussed" on major centers, while minor interaction nodes wither.

An anthropological evaluation of Keys' Ranch, in compliance with the provisions of the Historic Preservation Act of 1966, has resulted in the suggestion that the organization of materials at the Ranch reflects the Ranch occupants' perceptions of their roles and statuses within these shifting patterns of social interaction. The Ranch is thus a fruitful location for archeological study in combination with ethnohistorical and ethnographic investigation, as an example of human responses to the decline of "frontier" social conditions.

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OCMULGEE NATIONAL MONUMENT: PERIPHERAL SITES TUFT SPRINGS #1  
(13Bi25) and # 2 (13Bi19)

STOUTAMIRE, J. W.

The extensive 1930's WPA excavations in Central Georgia produced a large amount of archeological material from Ocmulgee National Monument and the surrounding area. Little of this material was reported on until Florida State University took over the curatorial maintenance of the SEAC collections. As part of this program the Two Tuft Springs sites, Late Archaic/Early Woodland to Late Mississippian campsites, were investigated. The lack of data from this time period within the park area for interpretive purposes combined with the obligation to report on this old material made these sites attractive for collections research. The results of this research are 1) a picture of aboriginal utilization of the river bottom resources during the above time frame, 2) refinement of techniques for dealing with problems of collections research on 40 year old material, and 3) the identification of research problems to guide future work.

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HOMAGE TO GUSTAVUS CHENEY DOANE

WRIGHT, G. A.

Archaeological research is being conducted in most of our National Parks. Our concern is not the immediate--e.g. the arrowhead or butchered bison--but the interrelationship of our genus with the environment. Archaeology's input into several aspects of park management is discussed from our work in Grand Teton.

According to its creation myth, the National Park idea was first conceived around the campfires of the Washburn-Langford-Doane Expedition of 1870. It was not the scientist, interested layman, or Congress, however, but Doane who first emphasized publicly the scientific, as well as touristic, value of the concept. As a scientific discipline, archaeology has several obvious roles. They include the intelligent planning of construction activities such as road and sewers which must be located so as not to destroy archaeological sites. Secondly, tourists are curious people. Archaeological data form a major basis for interpretative history.

Archaeology's responsibility goes well beyond this. It is stated that the primary purpose of the National Park Service is to maintain a park's ecosystem in a nearly pristine condition. But ecosystems change. Historic documents are insufficient for reconstruction. With its interest in human adaptations, archaeology uses several techniques to reconstruct the temporal and spatial variations in past ecosystems. Our results are relevant to the consideration of modern alterations.

Finally, site destruction outside of the parks is rampant. Our National Parks may become the last refuge of another endangered subspecies: the archaeological fieldworker.

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PROBLEM ORIENTATION, REGIONAL RESEARCH DESIGN AND MULTI-STAGE  
OPERATIONS--AN EXAMPLE FROM THE CONSERVATION ARCHEOLOGY PROJECT  
AT GUADALUPE MOUNTAINS NATIONAL PARK

MAYER-OAKES, WILLIAM J.

A project planned and partially completed at Guadalupe Mountains National Park (Texas) has defined regional research goals and methods based on the new ethic of conservation archeology. This kind of a research approach is partially reflected in the research design requirements of the developing Interagency contract archeology program. Acceptance of the conservation ethic provides a meeting ground for the traditionally basic or "academic" research interests and the salvage or "applied" interests. Such a meeting ground is presented in this brief review of two archeologies based on contrasting motivations.

Public parks and public lands are focal points for utilization of cultural, i.e., archeological resources. The emerging new ethic of conservation archeology recognizes cultural resources as non-renewable and mandates a specific range of acceptable "utilizations." These uses are often in marked contrast to the traditional academic (or scientific) utilizations which have been exploitative rather than conservational. The Guadalupe Mountains National Park has recently been the focus of a basic research interest to develop a methodologically sophisticated project fully embracing the conservation ethic. Substantive results of this work have been drastically limited by budget strictures. The research design for this unique region has incorporated theoretical problem orientations encompassing both culture history and culture process objectives as well as various methodological objectives.

Later development of a nation-wide program of contract archeology has independently developed an analogous but more limited concept of research design which is being widely disseminated. This concept of fundamental research design focuses on cultural resources and is used to determine federal financial support. The basic approach developed by the Interagency Services can be described as requiring a sophisticated achievement of culture history objectives, while encouraging creative problem objectives beyond this. Within the associated framework of a competition for contract proposal quality, the result of this research design attitude has been support for a variety of multi-stage project operations that match in many ways the basic research design drawn up for Guadalupe Mountains National Park.

With continued federal financial support, the new field of public conservation archeology may well effectively eliminate the old divisions between "pure" and "applied" research in U.S. archeology.

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HOW OLD IS CAPULIN MOUNTAIN?; CORRELATION BETWEEN CAPULIN MOUNTAIN  
VOLCANIC FLOWS AND THE FOLSOM TYPE SITE, NORTHEASTERN NEW MEXICO

ANDERSON, A.A.B.\*\* , HAYNES, C.V.\*\*

Based on exposures of the earliest Capulin Mountain basalt flow overlying a late Quaternary alluvial deposit in the Dry Cimarron River just above the town of Folsom, New Mexico, William Muehlberger has suggested that the Capulin Mountain eruptions occurred between 10,000 and 4,500 years ago and may have affected early aboriginal utilization of the area. He bases the former date on Kirk Bryan's correlation of the oldest period of alluvial deposition with the Folsom occupation and associated Bison antiquus; this bone recently yielded a collagen date of  $10,260 \pm 110$  (SMU-179) radiocarbon years ago. The radiocarbon date of  $4283 \pm 250$  (C-377) that Muehlberger uses as the upper limit is from a fire-reddened lens in a later deposit near the Folsom Site. This latter date has recently been substantiated by dates extracted from charcoal collected at other fire-reddened lenses in the same deposit. However, refinement and further subdivision of the local late Quaternary alluvial sequence suggests that Muehlberger's correlation with the Folsom deposit and B. antiquus could easily be erroneous and the initial Capulin Mountain eruption earlier than heretofore realized. This suggestion is further supported through radiocarbon dates produced by a baked organic soil directly underlying Capulin Mountain's earliest lava flow; the lower limit of the initial eruption may be at least 22,000 years ago and not have affected Folsom-age big game hunters.

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THE DEVELOPMENT OF A COMPLEX CULTURAL ECOSYSTEM IN CHACO CANYON, N. MEX.

JUDGE, W. JAMES

This paper views the Bonito Phase in Chaco Canyon as the end product of a gradually maturing cultural ecosystem which developed in the San Juan Basin from about 500 AD to 1200 AD. A basic assumption is that cultural ecosystems increase in diversity and stability during the maturation process in a fashion similar to other ecosystems. Diversity here is measured by the number of internal links between system components in the form of trade routes, as well as the number and nature of items traded.

It is suggested that the system developed in BM-3/P-1 times as a resource redistribution network linking Chaco Canyon with surrounding areas in order to compensate for fluctuating local environments. Initially based on reciprocity through kinship ties, the system matured into an increasingly complex and formalized trade network involving, perhaps, the use of turquoise as a form of "currency" by the mid-900's. Chaco Canyon emerged at that time as an essential component of the entire ecosystem, integral to and supported by the network of trade links due to its central location. As a result, the human population may have been able to depend on trade for resource acquisition by about 900 AD, and thus was no longer limited by the carrying capacity of the canyon environment. This would explain the puzzling occurrence of a large population during the Bonito Phase in an environment now thought to be marginal at best.

At the peak of the Bonito Phase (ca. 1100-1200 AD), the trade links may have been expanded to include formal economic ties with areas as distant as Mexico in an effort to increase system stability. This particular model, however, does not assume that such links were critical to either the development or the maintenance of the system. Its demise around 1200 AD is seen as a function of environmental perturbations at a number of the peripheral components, initiating resource depletion to a degree which exceeded the limits of the system as a whole.

Various kinds of environmental and cultural data, gathered under the auspices of the Chaco Center's research program, are examined in an effort to support the model.

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## THE HOVENWEEP ARCHEOLOGICAL PROJECT: A STUDY OF ANASAZI AGRICULTURE

WINTER, J.C.

The historic Pueblo farming economy developed over a period of several thousand years in the desert Southwest. The purpose of the Anasazi Agricultural Study at Hovenweep National Monument is to determine which, if any, of the Pueblo farming techniques were utilized at Hovenweep, and how they developed.

Since water is the master in the Pueblo environment, an elaborate social-religious-technological system has developed which insures moisture and exploits the little which is actually available. While certain aspects of Pueblo agriculture are very difficult to identify archeologically (e.g., ceremonial), the Hovenweep Project has demonstrated that the general patterns of economic development in the 4-Corner's area can be reconstructed. Field systems, water control devices, the domesticated and wild food networks, environmental relations, and to some degree the structure of the prehistoric farming community, are being identified through a multi-discipline program combining archeology, ethnobotany, palynology, geology, soil studies, gardening and water control experimentation.

The present paper describes one of the more visible and lasting effects of the prehistoric farming system at Hovenweep: the relations of modern plant distribution with past economic activities. On-site and off-site floral patterns in over four hundred locations have been used to determine the function of many ruins, particularly the so-called "water control devices." Over twenty species of wild plants have significant on-site distributions, and certain of these were once grown in the old gardens, as demonstrated by pollen studies.

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ARCHAEOLOGICAL RESEARCH IN NATIONAL PARK SERVICE AREAS: THE  
UNIVERSITY OF COLORADO EXAMPLE

BRETERNITZ, D. A.

For over 30 years the University of Colorado has been involved in a variety of archaeological research projects with and for the National Park Service. Some operations have been funded by the Service, some by research foundations, and some through University sources. The University of Colorado experience is an example of the breadth and depth, the variety and flexibility, of archaeological investigations which have been sanctioned and/or sponsored by the NPS.

Projects to be discussed, and illustrated, include the NPS areas of Dinosaur National Monument, Mesa Verde National Park, Rocky Mountain National Park, Colorado National Monument, Black Canyon of the Gunnison National Monument, and the Curecanti Recreation Area.

The various projects have been conducted for one or more of the following purposes: to meet compliance with Executive Order 11593; to satisfy Section 106 of the National Environmental Protection Act; for development/planning/management purposes; for evaluation of protection needs; for interpretative/visitor development; and, problem oriented investigations.

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PREHISTORIC SETTLEMENT PATTERNS IN THE BIGHORN CANYON NATIONAL  
RECREATION AREA, SOUTHCENTRAL MONTANA

LOENDORF, L. L.

During 1968 through 1976, archaeological reconnaissance work was accomplished in the Pryor Mountain-Bighorn Canyon area of south-central Montana. The primary goal of the work was to locate archaeological sites that might serve as visitor centers in the Bighorn Canyon National Recreation area and the adjacent Pryor Mountains. Intensive surface survey revealed approximately 450 archaeological sites. Testing has been accomplished on about thirty-five of the sites and excavation has been completed on eighteen sites, including some salvage excavation on sites in the path of a transpark highway. Descriptions of the sites and the artifacts recovered can be found in annual field reports that are filed with the Midwest Archaeological Research Center, National Park Service, Lincoln, Nebraska.

The purpose of this paper is not to describe the sites and artifacts found during the survey. Rather, it is intended to describe the settlement pattern that is evident from the spatial distribution of the sites and present the test of that pattern.

As stated by Binford (1968) the aims and goals of American archaeology are to construct culture history, lifeways and process. The spatial arrangement of archaeological sites and the diverse environmental settings in the Pryor Mountain-Bighorn Canyon area offer the prehistorian an ideal situation for research on lifeways. Lifeways research can be pursued within the limits of several theoretical frameworks. The general framework used here is to compare or contrast archaeological sites and their environmental settings.

Using factor analysis for comparison, a model of seasonal utilization of the resources was produced for the prehistoric period at Bighorn Canyon. This model was tested by using the distribution of lithic detritus in comparison to the indigenous sources of the material. The end result was a flow chart with scheduled activities of the prehistoric peoples through an annual cycle.

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CURRENT ANTHROPOLOGICAL RESEARCH, GRAND CANYON NATIONAL PARK

EULER, ROBERT C.

The appointment of the first professional anthropologist to the permanent staff at Grand Canyon National Park was made in September 1974. Current research involves archaeology, ethnography, ethno-history, and social anthropology.

Of first priority in archaeological research is the analysis and synthesis of data gathered in previous reconnaissance. This is being facilitated by the insertion of computerized data from 382 sites in the SARG (Southwestern Anthropological Research Group) data bank. Statistical manipulations that will either confirm or reject hypotheses relating to prehistoric cultural processes in Grand Canyon are being performed.

Analyses and a final report on the paleo-environment of Stanton's Cave, an Archaic split-twig figurine site also rich in Recent and Pleistocene biological material, are also being completed.

Additional projects are planned to conduct archaeological survey along the Canyon rims and on approximately 362,000 acres recently added to the Park.

Present ethnographical and ethnohistorical studies, coupled with archaeology, relate to traditional land use patterns by the Havasupai Indians in areas primarily below the rim of the Canyon.

Social anthropological investigations are beginning with efforts to understand present and past relationships between the National Park Service at Grand Canyon and the five adjacent Indian cultures: Havasupai, Hualapai, Hopi, Navajo, and Southern Paiute.

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THE ROLE OF THE NATIONAL PARK ON ST. JOHN, U.S. VIRGIN ISLANDS

GERBER, Stanford N. and RASMUSSEN, Knud

The purpose of the paper is to discuss the role of the national park on St. John, U.S. Virgin Islands. Problems to be explored include the economic consequences of the park on the Island, attitudes of St. Johnians toward the park, and potential problems to the Island resulting from the park.

Although the national park was initially seen by St. Johnians as a major contributor to the economy of the Island, from a St. Johnian perspective this anticipation has not materialized. Further, the St. Johnian population views the added governmental control since the establishment of the park as a threat to their security vis-a-vis land.

From the perspective of tourists to the Island, however, the park performs positive functions, ranging from low cost accommodations at Cinnamon Bay Camp to lectures and tours provided by the National Park Service.

These issues will be explored in detail and alternatives to making the park a more viable structure on the Island will be explored.

Data is based on extensive research on St. John dating from 1967.

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## ARCHAEOLOGICAL RESEARCH IN THE NATIONAL PARK SERVICE

SALZER, ROBERT J.

The deployment of a two-year archaeological project in the Apostle Islands National Lakeshore, Lake Superior, together with experience derived from other, similar, federally-sponsored projects in Wisconsin and Illinois, has raised questions about the relationships between the goals of scientific research and the needs of cultural resource management programs in our nation's public lands. This paper explores ways to resolve those questions.

Because logistical problems differ in different area, different levels of funding are required for each Park Service project. Private enterprise and agency archaeologists pose a special threat to archaeological data unless carefully controlled by the scientific community, and the proposed formation of local Archaeological Advisory Councils to oversee data collection and the development of responsible management programs is offered in an attempt to accomplish useful scientific objectives from the expenditure of public monies. The participation of students, for academic credit, in support roles on Park Service projects permits the more effective and efficient utilization of funds and also allows the recovered data to serve a broader constituency. Housing of resultant data at or near their place of origin permits ease of access to, and stimulates interest in, the prehistory of areas which are marginal to the major centers of cultural development in North America.

Since the data base of archaeology is fragile, finite, and non-renewable, the Park Service should seek mechanisms to integrate national research priorities and "problem"-oriented scientific research into their management programs

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## SUBSISTENCE - WHAT AND WHERE

BANE, G. RAY

The National Park Service is faced with a unique situation in the management of proposed new parklands within the state of Alaska. Significant numbers of Native and non-Native persons continue in varying degrees to rely upon resources and lands within proposed parks for meeting physical and cultural needs. The Park Service has committed itself to disrupt valid subsistence practices as little as possible in new parklands.

One of the major problems in managing subsistence is to determine what resources are being harvested and where subsistence activities occur. It also must gain a historical perspective on subsistence in order to determine areas and resources exploited in the past that may once again be utilized in the future depending upon such variables as game population dynamics, human harvest pressures, harvest technology, economy, etc.

During two years of intensive subsistence research among Native populations of northwestern Alaska certain tools have been designed to geographically display both area and resource utilization by subsistence dependent populations. These research techniques are also helpful in determining the historical perspective of subsistence.

This paper will describe subsistence research tools, findings, and possible uses in determining management within Alaska proposed parks.

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TIES THAT BIND: SOME CULTURAL DIMENSIONS OF KOYUKON SUBSISTENCE

NELSON, R. K.

This paper discusses some results of research on subsistence living among the Koyukon Athapaskans of north-central Alaska, whose traditional hunting grounds extend into the proposed Gates of the Arctic National Park. The modern Koyukon maintain intense philosophical and spiritual ties between themselves and the environment of which they are a part. This fundamentally conditions their perceptions of the world, and provides the basis for an elaborate natural history that differs in striking ways from our own. Specific aspects of this natural history are described, and the underlying environmental concepts are compared to those familiar in contemporary western societies. Culturally derived perceptions help to determine the nature of subsistence in Native communities, and must be considered in formulating policies for National Interest Lands in Alaska.

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## COPPER, GOLD, FURS AND OIL: A SOCIO-ECONOMIC HISTORY OF THE AHTNA

RECKORD, H.

The Ahtna Indians, sitting in the smoking shadow of Mt. Wrangell, in the proposed Wrangell-St. Elias National Park, have played an interesting role in the economic history of Alaska due to the wealth of their natural resources and their advantageous geographical location. Before contact, the Ahtna subsisted from their lands' rich resources, and held a central trading position in aboriginal trading networks as the central supplier of native copper. The society in which the Ahtna lived reflected the subsistence base from which they drew their sustenance and the trading relationships which substantially improved their basic lifestyle. Subsequently, the Russian and American influences changed the Ahtna way of life by binding each succeeding Ahtna generation more tightly to the Western economy. At first with the Russians, who were few in number and rarely visitors to the Wrangell region, the Ahtna were able to utilize traditional modes of social organization to successfully mediate the Russian influences, and in fact became highly successful middlemen in the fur trade. On the other hand, the Americanization of the area, erased the previous Ahtna control of the economy and society of the region. Any understanding of the history of the Wrangell Region would not be complete without a study of the Ahtna people, their historical relationships with their land, and their unique view of the region's history, as gained through the collection of oral history.

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WHAT'S COOKING IN THE CALDERA:  
MULTIPLE USE ON THE ANIAKCHAK COASTLINE

TUTEN, M. A.

The harvesting of natural resources for subsistence use by local villages occurs within the proposed Aniakchak Caldera National Monument on the Alaska Peninsula. Research extending beyond statistical analysis to include the broader perspectives of subsistence as it relates to the Aniakchak coastline has recently been conducted.

Chignik, Chignik Lake and Chignik Lagoon, the three villages nearest the proposed Monument on the Pacific side of the Aleutian Range, occupy a traditional yet transitory niche in the Aniakchak coastal environment. Cultural forces, although seemingly masked by rapid change, influence the psychology of the subsistence lifeway. The success of the commercial fishing industry and fluctuating employment opportunities complicate the extent of resource utilization within the proposed Monument. The future possibilities of rising fur prices, energy development and increased communication will affect to varying degrees their use of the land. The nearby Aniakchak coast supports such activities as well as competition for resources with distant subsistence and sport hunters.

Complex subsistence information must be identified and utilized by Park Scientists and Planners to comprehensively manage the Aniakchak proposal for multiple use.

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## ETHNOHISTORY OF THE KALTAG PORTAGE, ALASKA

KOUTSKY, K. AND E. ANDREWS

The Kaltag Portage exemplifies the types and degree of contact and exchange among three diverse cultures--Indian, Eskimo, White--during the 19th and early 20th centuries in midwestern Alaska. In this paper we will report the changing utilization and significance of this route using historic sources as well as information from native oral traditions.

Extending 90 miles between Kaltag on the Yukon River and Unalakleet on Norton Sound in the Bering Sea, this portage provided an avenue of aboriginal trade between Indian and Eskimo groups during the early 19th century. With the introduction of items of non-native manufacture, this trade flourished and a number of native villages were established along the Kaltag Portage. These villages were occupied by a group of specialized native traders who monopolized trade between the coast and western interior Alaska. As Euro-American trading centers became more localized on Norton Sound and the Yukon River, specialized traders became less significant, facing competition in the amounts and kinds of goods offered by the non-native traders. Waning in significance as a trade route, the Kaltag Portage persisted as a communication corridor between the coast and interior Alaska. While a military telegraph system and U.S. mail trail developed along the portage in the early 20th century, native peoples continued to maintain their traditional intercultural contacts.

Information from historical documents as well as native oral accounts reflecting the multiple uses of the Portage by natives and whites alike are brought together in order to examine the varying roles that each group played in the history of this trade and transportation route.

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MARINE MAMMAL SUBSISTENCE PATTERNS OF THE YUPIK ESKIMO OF THE BERING  
SEA COAST, ALASKA

HANSEN, S. K.

In the Yukon-Kuskokwim delta and along the Bering Sea Coast of Alaska, marine mammals still play an important role in the subsistence patterns of the Yupik Eskimo.

In 1974 a study was conducted by Calista Corporation, the Native regional corporation, which revealed information on the present day marine mammal harvest patterns, utilization and the relative importance of coastal areas for hunting marine mammals. Information was gathered from approximately 66% of the families residing in 18 Yupik villages. These results are compared with similar subsistence studies conducted before 1974 and in 1975.

The information was used in making land selections under the Alaska Native Claims Settlement Act. It is also important in weighing the relative importance of oil development in the coastal regions and its possible effect on marine mammal resources of that area.

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THE CASE OF FEODOR BASHMAKOFF: AN ETHNOHISTORICAL STUDY OF NATIVE-  
WHITE CONTACT IN NINETEENTH-CENTURY SITKA

STEIN, GARY C.

Cultural contact and reaction is an important theme in Alaskan Native history, and the most intensive contacts resulted from Russian missionary activities in the eighteenth and nineteenth centuries. This paper will discuss one type of Native reaction to missionary endeavors.

Feodor Bashmakoff was a Native Tlingit of Sitka, the capital of Russian America. He eventually became a subordinate priest of the Russian Church. In 1829 Church authorities accused Bashmakoff of sorcery, as he had been seen assisting a Tlingit shaman in a healing ceremony. He was also accused of dipping "pagan charms" into holy water and selling them back to the Natives.

Tesitmony against Bashmakoff--taken mainly from baptized Natives--reveals that he may have been a shaman himself, or perhaps that his priestly office was considered by the other Indians as merely another form of power to be called upon in time of need. Church authorities finally exonerated Bashmakoff--he voluntarily decided to spend the rest of his life in a Siberian monastery--but realized that a more rigorous examination would have to be made into the characters of future Native clergymen.

The case of Feodor Bashmakoff provides an insight into Native reactions--individual and community--to Russian cultural intrusion into their lives, and may indicate new directions for future studies of Native-White contacts in Alaska.

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## ARCHAEOLOGICAL SAMPLING TECHNIQUES IN ALASKA

SHIELDS, HARVEY M.

Most archaeological surveys in Alaska tend to be carried out on an intuitive basis. In order to change this practice a survey method new to Alaska was attempted on two archaeological surveys.

All too often in Alaska only "good" locations are examined to determine the existence of archaeological sites. While this method certainly leads to discovery, it neglects alternate possibilities. The lack of statistically useful data makes analysis for the purpose of predictive modeling virtually impossible. A major reason for the continuation of this method is the dense ground cover that characterizes most of Alaska. To circumvent this problem as well as eliminate investigator bias, a technique new to Alaska was attempted on two National Park Service sponsored surveys, one in the Lake Clark area and one along Bristol Bay. The surveys were restricted to shorelines and included a 10% stratified sample of the investigated areas. Each sample area was intensively tested through the use of shovel probing. This allowed the investigators to inspect the ground beneath the dense vegetation. While the results are not conclusive for the entire state they are indicative of the effectiveness of this technique in southwest Alaska.

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EXAMINATION OF A 1600 YEAR OLD FROZEN NATURALLY MUMMIFIED TATTOOED BODY  
FROM ST. LAWRENCE ISLAND, ALASKA

SMITH, GEORGE S.

The finding of a frozen naturally mummified body in Alaska provided the rare opportunity to examine an individual who lived more than 1600 years ago.

The body, that of an adult Eskimo female, was found on St. Lawrence Island located in the Bering Sea some 118 miles from the mainland of Alaska and 39 miles from Russia. Tissue from the body was radiocarbon dated at  $1661 \pm 81$  years: A.D. 289 by the Smithsonian Institution. The body was flexed at the elbows, hips and knees. The skin was dark brown and moderately dried out. The teeth showed marked attrition typical of the Eskimo dentition. Extensive tattooing was found on both arms.

A complete medical examination was performed with the following results. The age at death was estimated to be 50 years of age. Death was found to be by asphyxiation. The lungs showed adhesions to the chest wall and diaphragm, indicative of pneumonia. The lungs also showed heavy deposition of carbon pigment, no doubt due to a life spent around open fires.

Elaborate tattooing was found on both the right and left forearms, hands and fingers. The tattooing motif correlates with the design motif of the Old Bering Sea period (300 B.C. - A.D. 500) of St. Lawrence Island prehistory, which correlates with the time period indicated by the radiocarbon dates.

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## CHEMICAL METHODS OF RUINS STABILIZATION

FENN, D. B.\*, BURGE, R. E.\*\*

Chemical methods for treating prehistoric and historic ruins have long been sought by National Park Service personnel. This paper reports on studies underway in Chaco Canyon National Monument and Fort Bowie National Historic Site utilizing 35 different chemical products in a testing program on mortar, adobe and sandstone.

Four major problem areas are being investigated in this study, namely stone decay, adobe erosion, mortar erosion, and pithouse wall erosion. In July 1975, the first mortar stabilization test plots were established at site 236 in Chaco Canyon. Three chemicals were used. By October 1975, one of the chemicals, a polyvinyl chloride, was failing due to ultraviolet radiation discoloring while the other two chemicals, both emulsified acrylic polymers, are still holding up well after one year. In October 1975, the mortar tests were expanded to Site SJ-1912, known as Lizard House, using an acrylic ester resin and five more acrylic emulsion polymers.

In October 1975, the first pithouse wall stabilization tests were established at Chaco Canyon. Nine chemicals were sprayed on 6' x 2' test plots. In February 1976, one of the chemicals, an acrylic emulsion, was failing but the other eight still looked good.

In July 1976, the first stone preservation tests were established on a specially built test wall at Chaco Canyon. Fifteen chemical products were sprayed on 4' x 4' sections of the sandstone wall. Water will be applied to the foundation soil at selected intervals to promote wicking action into the sandstone and to accelerate the potential for stone decay. The treatment will be monitored for effectiveness.

The first adobe preservation tests will be established on a specially built adobe test wall at Fort Bowie in August 1976. Nineteen chemical products will be tested. Stabilized adobe will be made with the chemicals and unstabilized adobe will be spray-treated. The treatments will be monitored for effectiveness.

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## PRESERVATION OF ROCK ART

TURNER, CHRISTY G., II, BRADSHAW, RICHARD L. AND BURKE, WILLIAM J.

The slow, natural deterioration of prehistoric rock art has been greatly accelerated in recent times by the intrusion of forces of civilization. This paper is concerned with research directed toward the preservation of rock art by a procedure involving the in situ polymerization of vinyl monomers.

Major emphasis in this study is concerned with a study of selected reaction variables in the polymerization of methyl methacrylate within representative types of sandstone found in Northern Arizona-Southern Utah regions containing significant examples of rock art.

Placement of a sandstone sample in a shallow layer of methyl methacrylate containing benzoyl peroxide as an initiator was found to be a convenient means of inducing polymerization of the monomer throughout the sandstone structure. The in situ polymerization of methyl methacrylate in this manner at 30°C over a period of several days resulted in a dramatic improvement in cohesive strength and water resistance of representative types of sandstone.

Data obtained with the scanning electron microscope and the electron microprobe clearly showed that the in situ polymerization of methyl methacrylate is capable of completely embedding sand grains and binding them together in a polymer matrix.

The results obtained in this research indicate that the in situ polymerization of methyl methacrylate under controlled conditions offers attractive possibilities for the protection of rock art.

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## MAGNETIC SURVEYING OF ARCHAEOLOGICAL SITES

WEYMOUTH, JOHN W.

Under favorable conditions subsurface features of archaeological interest such as foundations, filled ditches, fire pits and even cache pits can cause a slight but measurable anomaly in the earth's magnetic field near the feature. Thus measurements of the earth's magnetic field over a controlled grid of points two to three feet above the surface can reveal isolated features or structural patterns of archaeological interest. The size of the effect and therefore the ability to observe the anomaly depends on the magnetic properties of the source relative to that of the surrounding soil.

We have accumulated several years experience in surveying sites in the Central Plains states and have developed field techniques and computer programs for the analysis and interpretation of the data. We shall discuss the theory and practice of magnetic surveying with examples. In particular, we shall report on the results of two surveys conducted for the Midwest Archaeological Center, NPS.

A survey conducted in 1975 on the prehistoric Walth Bay site (39WW203) in South Dakota revealed a number of house fire pits and cache pits verified by subsequent soil probing.

A survey conducted in 1976 in an area adjacent to Fort Laramie, Wyoming resulted in an extensive pattern of anomalies extending about 100 feet which has been interpreted as belonging to a foundation location for the Ward and Guerrier Trading Post of 1857-58. The location of this Post was desired in connection with the development of a visitor's center and parking lot.

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## REMOTE SENSING METHODOLOGY IN ARCHEOLOGY

LYONS, T. R.

Remote Sensing is considered by many as a science in its own right. For the archeologist, it provides a scientific methodology by means of which absolute or relative measurements are obtained, processed, and interpreted. The procedures are directed to the identification and resolution of problems and the testing of hypotheses.

One of the specific archeological problems to which remote sensing techniques have been applied at the Chaco Center is the mapping and analysis of the prehistoric Chacoan roadway system of Northwest New Mexico and adjacent areas.

Black and white aerial photography flown in the 1930's, 1950's and 1960's proved to be useful in identifying road traces not visible on the ground. For the purpose of identification a recognition pattern was developed and electronic laboratory equipment employed. Approximately 250 lineal miles of roadway have been mapped and the interregional character of the system recognized. The mapped roadways and associated features were field checked and studied on the ground.

Early historic records were checked for references to roadways and several definitive statements about such constructs were found.

Inferences were derived concerning the origin, extent and functions of the system, and the technological sophistication required for its development.

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UNDERWATER ARCHEOLOGY IN THE NATIONAL PARK SERVICE

LENIHAN, DANIEL J.

The National Park Service has been engaged for several years in an active underwater archeological program. In keeping with an overall cultural resource management framework, the emphasis of in-park studies has been site inventory rather than excavation. With the exception of early investigations in Montezuma Well and the present nation-wide reservoir inundation project, these studies have focused on historic shipwrecks in the Southeast Region.

This paper will discuss the nature of underwater archeology when used as a cultural resource management tool and examine briefly the specialized techniques which National Park Service archeologists have been using or are presently developing to extend archeological research to the aquatic environment.

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THE INUNDATION STUDY: A UNIQUE APPROACH TO CULTURAL RESOURCE MANAGEMENT

CARRELL, TONI

The National Park Service is the coordinating agency for a multi-phase study to determine the effects of freshwater inundation on archeological sites. The focus of the study will involve examination of submerged sites to assess the impact on their data retrieval potential, degree of preservation or destruction of archeological remains and the efficacy of salvage operations versus direct protective measures.

The paper will outline the historical development and nature of the inundation study. The various aspects of the research program to be examined will include: project goals, theoretical orientation, developments in the research design, and assessment procedures used to determine which reservoirs and sites are viable for intensive testing. The technical advances made by the Inundation Team to deal with the problems of high altitude and decompression diving, provenience control and data recording, mapping techniques and sampling procedures, etc. will also be discussed.

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## HISTORIC SITE LOCATION THROUGH SCALE REDUCTION AND GRAPHICS

EHRENHARD, JOHN E.

Scale reduction and graphics generated by the CDC-6000 computer and Gould plotter at Florida State University show topographic modifications of Cumberland Island, Georgia since 1802. This paper reports on studies of these modifications and their relationship to historic structures of the middle 18th century.

Fort William and Fort Saint Andrews, the first coastal defenses erected on Cumberland by the Georgia colonists, played an important role in the struggle between Spain and England during the War of Jenkins' Ear (1739-1743). Published descriptions fail to accurately pinpoint their locations, and maps giving their emplacement lack accurate detail. Field reconnaissance failed to locate these sites.

Subsequent research was undertaken using a previously undiscovered map of the island (circa 1802) and a current topographic sheet of the same area. The two maps were digitized and translated into cartesian coordinates. A scaling factor was computed and the 1802 chart was reduced in size to that of the 1975 topo. Polygons describing the fort locations were extracted from the 1802 map and inserted onto the current quadrangle. Further processing produced a Gould plot describing their probable emplacement. Overlays revealed the extent of topographic change during the last 174 years and provided supplementary data pertaining to island erosion and dune migration.

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## IMPLICATIONS OF RAINFALL RECORDS AT MESA VERDE NATIONAL PARK

INGMANSON, J. E., AND COLYER, M. A.

With minor exceptions the National Park Service has recorded monthly precipitation totals from the headquarters area in Mesa Verde National Park since 1923. These records have been examined to seek illustrations of dominance of either winter or summer storm patterns and support for various modals of climatic change in the thirteenth century.

The data show a modest winter dominance in the rainfall pattern since 1923, but they also suggest an enhanced relative importance of summer precipitation during the last 25 years. When the recorded rainfall patterns of the past 53 years are compared to published reconstructions of climate in the northern Southwest, the current patterns are seen to resemble those of the period following the abandonment of the area by the Anasazi more closely than those rainfall patterns thought to be prevalent at an earlier date (A.D. 900-1100) when a large population is postulated. The period from 1951 through 1975 seems to resemble the period of heavy prehistoric population slightly more than does the period from 1923 through 1950.

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THE IMPACT OF MAN ON NATIONAL PARK SERVICE AREAS  
FROM PREHISTORY TO THE PRESENT

COTTER, JOHN L.

The National Park Service maintains many areas which have been influenced by human activity in one degree or another since the Paleo-Indian period. To date, no attempt has been made at tracing this activity. Systematized longitudinal studies, utilizing ecological and anthropological data are absent. Within the past year the National Park Service initiated a contract with the University of Virginia, represented by Dr. Michael Hoffman as Principal Investigator, which has as its objective the complete study of the continuity of man's utilization of the Shenandoah National Park area beginning with the first recognized occupation. Involved are interdisciplinary ecological investigations including studies of the geology, fauna, flora and man. Human occupation is traced from the Paleo-Indian through Archaic early Middle and Upper Woodland periods to the time of discovery of the area by the Europeans. The study continues with the recording of historic settlements, industries, folk arts and crafts and the life ways of the mountain people who live along the Appalachian ridge in the park as well as the involvement of the National Park Service which has had major influence on the area.

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II. AQUATIC BIOLOGY

RESEARCH ON ENDANGERED FISHES IN THE NATIONAL PARKS WITH SPECIAL  
EMPHASIS ON THE DEVILS HOLE PUFFISH

DEACON, JAMES E.

Changes in underwater habitats, beginning with fish planting, have occurred for many years in the National Parks. Recently the pace has quickened as man's utilization of his environment has become more thorough and farther reaching. Dams on the Colorado River and wells in the desert provide examples of mans impact on fishes in National Parks of the southwest.

The Devils Hole pupfish population in Ash Meadows declined as a result of lowering water level in their only habitat. Their annual population fluctuation appears closely dependent on primary productivity which in turns is largely dependent on the deviation of direct sunlight at the water surface. Maximum population size appears to be a function of the size of the habitat available to them in Devils Hole. Reproductive seasons, food habits and fluctuations in populations of invertebrates in Devils Hole have also been defined.

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LIFE AT HIGH TEMPERATURES: THE YELLOWSTONE EXPERIENCE

BROCK, THOMAS D.

For ten years, the author carried out an extensive field research program in Yellowstone National Park, studying life in the geyser basins. This program had four distinct rationales, ecological, evolutionary, taxonomic, and practical. The geysers and hot spring run-offs were viewed initially as simple ecosystems where general ecological problems could be studied more easily. It soon became clear that the results of the work would have general evolutionary significance, since they revealed important aspects about how organisms could adapt to specific environmental influences. During the course of the research, a number of new organisms were discovered, which had to be described and characterized. Finally, the thermal and acid effluents of Yellowstone springs entered normal rivers and lakes, and the response of organisms in these waters to "natural" pollutants could be studied. Although the field research was carried out exclusively in the Park, it became essential, because of Park Service restrictions, to set up the extensive laboratory facilities needed at a location outside the Park boundaries, in West Yellowstone, Montana. During the course of this ten year research study, the author also visited the major geothermal habitats in other parts of the world. More than anything else, these visits demonstrated the uniqueness of Yellowstone, and emphasized the importance of having this priceless resource as a relatively undisturbed national park. Some suggestions will be made about how research in national parks can be promoted, and how priorities can be drawn between conflicting interests and uses.

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MARINE RESEARCH IN VIRGIN ISLANDS NATIONAL PARK

RANDALL, JOHN E., AND RANDALL, HELEN A.

Many aspects of the biology of marine fishes can be ascertained by means of underwater observations. Development of scuba equipment and underwater cameras has permitted quantification of behavioral activities such as symbiotic cleaners. The movie will show many of the possible research activities that can be done in underwater parks.

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ASSOCIATION OF PHYTOPLANKTON PHOTOSYNTHETIC RATES WITH VERTICAL  
TEMPERATURE AND LIGHT TRANSMISSION GRADIENTS IN CRATER LAKE, OREGON

LARSON, D. W.

Crater Lake, Oregon, the deepest lake in the United States, features unusual transparency and thermal gradients. The lake may show the greatest transmittance of light of all natural waters. Temperatures during summer seldom exceed 5° C at depths below 40m, and 4° C below 100m.

Maximum productivity and the largest concentration of chlorophyll a in Crater Lake during summer 1968 and 1969 occurred at depths where temperatures were near 4C and measurable light < 4% of surface illumination. It is suggested that the phytoplankton in the lake consists mostly of oligothermal-oligophotic populations that are limited to depths greater than 70 m in summer, but occupy the 0-70-m stratum in winter, so that a rather constant rate of production per unit area is maintained throughout the year.

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SPATIAL AND TEMPORAL DISTRIBUTION OF ALGAE AND SELECTED WATER  
QUALITY PARAMETERS IN THE BUFFALO RIVER, ARKANSAS

MEYER, R. L., AND RIPPEY, L. L.

The major objective was to provide a baseline study of the chemical and physical characteristics of the river along with the spatial and temporal distribution of algae. Such a study will be useful to the National Park Service in determining if the river's anticipated increased use has had any effect on the water quality.

Algal flora of the river was found to be predominantly periphytic, though planktonic populations developed to a minor extent in periods of low water levels. The availability of various surfaces for the attachment of periphytic algae was one of the factors determining algal distribution. Epilithic periphyton was observed most frequently but epiphytic and epizoic populations also were found.

Algal distribution seems to be most clearly determined by water level, flow rate, and flooding. Other factors affecting distribution were water chemistry, light, and temperature fluctuations.

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A SYSTEMS APPROACH TO MANAGEMENT OF SPANISH POND,  
FORT CAROLINE NATIONAL MEMORIAL

Harris, L. D., and Kautz, R.

Spanish Pond at Fort Caroline National Memorial, Florida has a longer historical legacy than any other pond in North America. An assault force of Spanish camped here in 1568 before routing the French from Fort Caroline. A Paleo-ecological interpretation allowed reconstruction of pond history while systems analysis was used to project the pond's trajectory into the future. Because of a suburban location the 4 ha. pond is subject to residential runoff, management pressure and public scrutiny.

Despite its appearance of rapid change to a terrestrial system, the pond seems to have been in a nearly steady state until recently. In the 1930's timber harvest to the pond's edge caused an increase in water level which probably drowned low growing willow (Salix sp.) and buttonbush (Cephalanthus sp.) rookery trees. In 1969 pressure to control mosquitos caused the installation of an artesian well. Use of the well to stabilize water levels caused anaerobiosis, turbidity, lowered pH and disruption of the food chain. The combination of reduced food resources and rookery destruction forced the birds to leave. Gas analysis of primary production and experimental decomposition studies suggest that the stabilized water level greatly accelerated succession to a terrestrial system by encouraging the more productive emergent vegetation community while slowing decomposition of submerged sediments.

A fluctuating water level which alternately encourages the floating plant community and oxidizes sediments will best perpetuate Spanish Pond. Allowing the encroachment of trees to the waters edge would reduce the pond to a size comparable to what it was when the Spanish first camped there 400 years ago.

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WETLANDS PRIMARY PRODUCTIVITY ADJACENT TO ACADIA NATIONAL PARK, MAINE,  
AND CUMBERLAND ISLAND NATIONAL SEASHORE, GEORGIA

REIMOLD, ROBERT J.,<sup>1</sup> LINTHRUST, RICK A.,<sup>2</sup> AND HARDISKY, MICHAEL A.<sup>1</sup>

Modern ecology has demonstrated the usefulness of environmental baseline studies to assess ecologically sensitive and important areas. The most probable major advance in environmental analysis is the thorough consideration of primary and secondary ecosystem production. Primary production of coastal salt marshes is a fundamental characteristic and basis for estuarine food chains. This study was designed to assess temporal and latitudinal variations in salt marsh primary production of wetland areas adjacent to Acadia National Park, Maine, and Cumberland Island National Seashore, Georgia.

Salt marsh primary production and resultant detritus production were assessed at eight week intervals for a three year period. Associated parameter measurements included stem density, live - dead ratios, rates of disappearance, as well as associated meteorological and tidal information. Simultaneous dates of collection and similarity of methodology were implemented to permit comparisons of data from the two different geographic areas. The salt marsh plants evaluated included: Borrichia frutescens, Carex sp., Distichlis spicata, Iva frutescens, Juncus balticus, Juncus gerardi, Juncus roemerianus, Salicornia virginica, Spartina alterniflora, Spartina cynosuroides, Spartina patens, and Sporobolus virginicus.

The results document the similarities of primary productivity in the two areas. Although the growing season is much shorter in the northern latitudes, the increased density of stems per unit area accounts for the greater similarity in primary productivity on an annual basis. Detritus production appears to be more important in the southern latitudes in sustaining productivity of the surrounding estuarine water system. Not only Spartina alterniflora but also a number of the other plants considered do have a high rate of primary productivity. Any future land use planning should involve weighing the primary productivity of these "minor marsh plant" species.

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## Aquatic Microbial Studies in Grand Teton National Park

McFeters, Gordon, A. and Stuart, Sidney A.

Studies were conducted within Grand Teton National Park, Wyoming, to investigate the nature and extent of recreational impact on the water microbiology within this alpine park. This effort was initiated to aid park officials in determining whether existing management policies were resulting in water quality deterioration that could be a health hazard to park visitors. In addition, it was hoped that the information gained would be of value in guiding the policy making process relative to visitor use management.

Selected waters from the high alpine zone within Grand Teton National Park, Wyoming, were studied during the past four summers to determine the influence of various factors on the quality of these waters. The water samples collected were analyzed for populations of indicator bacteria. Water that originated in remote areas contained some indicator bacteria and these populations increased as the water flowed toward the valley. In general, the magnitude of this increase was not significantly influenced by the presence or absence of human visitors but, rather, by the nature of the biological community through which the streams flowed. It was determined that it is possible for coliforms of the non-fecal type to grow and multiply in alpine streams using extracellular products excreted by algae but it was not determined to what extent (if any) this occurs in Grand Teton National Park. Once in the valley lakes, the indicator bacteria declined to very low levels. A minority of the coliforms that were recovered from all of the sites proved to be fecal coliforms. The fecal streptococci isolated were identified as the species that were found primarily in the fecal material of the native rodent and moose populations. It is concluded that management questions that relate to the carrying capacity of alpine areas should be approached with the aid of other biological parameters along with levels of indicator bacteria in the streams.

Samples were analyzed from Cottonwood Creek to examine the impact of various "road-side" human activities on the water microbiology of this valley stream. Significant levels of indicator bacteria were found. A horse corral was implicated as the source of this water contamination by the use of selective sampling and the fecal coliform to fecal streptococcus ratio.

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STUDIES INTO THE AQUATIC RESOURCES OF GULPHA GORGE CREEK  
HOT SPRINGS NATIONAL PARK, ARKANSAS

Ogra, M. S., Sims, A. C. and Rai, G. S.

Preliminary studies on chemical and microbiological analysis of Gulpha Gorge Creek water was carried out employing conventional methods of analysis and germanium lithium detector using multi-channel analyzer for characteristic gamma rays. Investigations revealed that the influence of human activity on the stabilization forces acting on the creek water was minimal.

Water samples were collected from seven locations along the course of the water shed during 1974 and 1975. On the spot determination indicated high dissolved oxygen levels with pH ranging between 7 and 7.4 which indicate absence of organic loading. Chloride levels were generally low average being 10 mg/l as NaCl. Nitrate concentrations ranged between .1 to 1 mg/l. Concentrations for sulfates and nitrates were markedly low. Similarly phosphates and nitrogen were detected only in minute quantities ruling out any domestic pollution or agricultural run offs. Hardness evaluated as  $\text{CaCO}_3$  ranged between 32-128 mg/l which was well below the normal values in most natural waters.

Most probable number (MPN) for coliforms varied from 25 - 540/100 ml. No definite correlation was observed between total coliforms and temperature or pH of creek water. Variations in MPN from location to location were not marked. Incidence of fecal coliforms was very low, MPN being 10-40/100 ml.

The vegetation found on the course of the water shed was the usual found in disturbed stands of a climax of the mixed mesophytic forest.

These values suggest that camping grounds, hiking or other activities had minimal effect on the creek water. It may be observed that whereas human element did not disturb the ecosystem of the Creek, the Creek water did not seem to be a threat to human exposure.

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BACTERIOLOGICAL ASSESSMENT OF FRESH WATER PONDS AT THE CAPE COD  
NATIONAL SEASHORE

Ortiz, Jesse S., Steven Sousa, William L. Levine and Norman R. Ward

Fifteen fresh water ponds in the Cape Cod National Seashore were tested during the summer of 1975 for various bacterial indicators of water pollution; including total coliform, fecal coliform, fecal streptococci, coagulase positive staphylococci and *Pseudomonas aeruginosa*. In spite of low fecal coliform counts, four of the ponds heavily used for swimming consistently harbored coagulase positive staphylococci and *Pseudomonas aeruginosa*. Biochemical tests on isolates from the fecal coliform plates showed the presence of *Klebsiella pneumoniae* and also the possibility of the presence of *Shigella* organisms.

Concomitant with the pond study, physicians collected ear, nares and throat cultures from patients who had been swimming in the ponds and had developed clinical symptoms. Phage typing on staphylococcal isolates from both patients and ponds indicated some ponds as a possible source of infection to swimmers. Further research on the four incriminated ponds is being conducted during the summer of 1976.

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WARMING PROCESSES IN THE KAWEAH RIVER  
SEQUOIA NATIONAL PARK, CALIFORNIA

Abell, Dana L.

Diversion of water for power production from the Kaweah River in Sequoia National Park reduces flow in summer to as little as one third of the natural volume of 35-60 cfs. and provides an opportunity to test the conflicting assumptions that (1) reduction of flow results in higher water temperatures and (2) that free-flowing streams remain in equilibrium with the temperature of the air, whatever their size. The study raises questions, in fact, on the whole process of warming in montane streams.

Streams in the southern Sierra normally warm a half a degree Fahrenheit per mile but do so discontinuously. Temperature-stable reaches (warming rates less than 0.2 degrees F. per mile) that are two or three miles in length alternate with much shorter warming reaches. Rates of warming in natural streams appear to exceed 2 degrees per mile only rarely. Higher rates occur where man has altered natural flow, e.g., up to 5 degrees per mile for short distances below river-run powerhouses and up to 10 degrees per mile below high dams. A warming rate of 4.6 degrees per mile (data from 1975 only) in the first half mile below the Kaweah diversion in summer indicates a significant immediate effect attributable to this alteration of flow, but over-all warming in the 4.5 miles to the power house tail race is practically the same at 14, 20 and 120 cfs. Temperature accrual curves for that distance show rapid, then slow warming at low flow but more gradual warming, which never exceeds 2 degrees per mile, at 120 cfs., which is a relatively high discharge level. Those same curves show finer-scale discontinuities, including at least one reach of occasional temperature loss. Continuing studies by the National Park Service are expected to clarify these observations.

Correlation of these shorter discontinuities with aerial photographs indicates that heat input is high where broad, shallow riffles predominate and that pools are associated with the temperature-stable reaches. The actual warming process appears to depend upon a favorable relationship between time of flow and the combined factors of heat input, mixing, and low back-radiation.

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ACID DRAINAGE TOXICITY AND ASSESSMENT OF LIME NEUTRALIZATION IN STREAMS  
OF THE GREAT SMOKY MOUNTAINS

MATHEWS, R.C., SINKS, J.D.\*, AND MORGAN, E.L.\*

Road construction and natural outcroppings of the Anakeesta sulfide mineral formation in the Great Smoky Mountains National Park has produced mineralized, acid runoff in areas of exposure. Streams receiving acid drainage may have a severely altered biological component, the level of impact being a function of acid loading. In this study, toxilological assessments are made of Shovelnose salamander larvae (Leurognathus marmoratus) subjected to a regime of Anakeesta leachate concentrations and a series of lime neutralization solutions of the leachate. The purpose of these tests is to provide insight into possible management alternatives for acid stressed streams in the Park.

An array of toxilological tests employing various concentrations of stream water saturated with Anakeesta leachate, established lowered pH values and increased component metal concentrations toxic to the shovel-nosed salamander larvae. In order to evaluate the effectiveness of a management alternative, subsequent assessments utilizing lime as a neutralizing agent were performed. Increased pH levels, decreased heavy metal concentrations and reduced mortality were observed after stabilization. Information gained from these studies are discussed in light of Park management strategies.

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LIMNOLOGICAL RESEARCH ON THE COLORADO RIVER AND SELECTED  
TRIBUTARIES IN GRAND CANYON NATIONAL PARK, ARIZONA

KUBLY, D. M. AND G. A. COLE

Investigations of the Colorado River were carried out during 1975-76 on five float trips from Lee's Ferry (Mile 0) to Mile 225. In this paper we report on the physico-chemical nature of the mainstream and its modification due to the influences of certain tributaries which enter in this region.

Colorado River waters at Lee's Ferry issuing from Glen Canyon Dam some 16 miles upstream are cold (7-10 C) and highly transparent. Surface temperatures increased seasonally to only 15.2 C at the far downstream location. Flooding in the Paria and Little Colorado Rivers at times reduced mean vertical light penetration in the mainstream from 75% to 0.001% per meter.

Tributary influences on dissolved constituents were much less marked though most tributaries deviated notably from the mainstream in ionic composition and concentration. Typical initial mainstream ionic rankings in meq/liter were:  $Ca^{++} > Na^{+} > Mg^{++} > K^{+}$  and  $SO_4^{=} > CO_3^{=} > Cl^{-}$ . Only calcium and sodium showed a tendency to change positions in the downstream reach. Mean total dissolved solids in tributary waters ranged from 209-2141 mg/liter while mainstream values ranged from 623-676 mg/liter. Lowest mean values occurred at Mile 0 with a mean increase in salts of 20 mg/liter (3%) at Mile 225. Intermediate locations usually exhibited highest values mainly due to the input of saline waters from the Little Colorado River. Subsequent amelioration of this effect by other dilute tributary waters resulted in the decreased salinity values seen downstream.

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A LIMNOLOGICAL SURVEY OF BASS LAKE, POINT REYES  
NATIONAL SEASHORE, 1976

WIDMER, C.

Data on water temperature, transparency, dissolved ions, phytoplankton and zooplankton are being collected. Findings to date are reported here. Because of the equable marine climate, tropical characteristics may exist in Bass Lake despite its temperate latitude (approx. 38° N).

Bass Lake (surface: 3 ha.; volume:  $4 \times 10^5 \text{ m}^3$ ; depth: 17 m) is one of several small lakes formed by the filling with water of depressions behind sliding masses of land in the Double Point area of the Point Reyes National Seashore. The main inflow is a rivulet on the east side of the lake. A second inflow occurs on the south side. The chemical composition of these inflows differ. The lake drains into the Pacific Ocean about 0.8 km to the west.

Bass Lake was homothermal during January and chemical evidence indicates mixing at this time. Stratification started in February, and a well-developed thermocline (6 to 9 m) was in evidence by mid-April. At this time the hypolimnion became depleted in oxygen and  $\text{H}_2\text{S}$  began to build up. Increased concentrations of ammonia and ortho-phosphate were also observed.

After mixing, phosphate levels in the upper waters were as high as 0.9 mg/l. After thermal stratification these fell to 0.1 mg/l by mid-June.

Nitrate nitrogen was found at around 0.3 mg/l in February.

Samples of water for the enumeration of phytoplankton are taken, and vertical hauls (15 m) with a No. 12 mesh net are made for the collection of zooplankton. Zooplankton are abundant. No small fish have been observed.

The water is usually very transparent with Secchi disk readings around 9 m. Only in late February was the Secchi reading as little as 3 m. This was probably due to an abundance of phytoplankton rather than silt, since there was a scarcity of rainfall and inflow waters remained clear.

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THE LIMNOLOGY OF FRESHWATER KETTLE PONDS OF THE CAPE COD NATIONAL SEASHORE

SOUKUP, MICHAEL

Twenty freshwater ponds, many of which have shoreline homesites and heavily-used public beaches, are being investigated to establish their limnological character and the extent of impacts received from past recreational use.

The watersheds are sandy glacial outwash plains, with poor soils and high infiltration. The ponds are thus seepage lakes, generally small (0.5 to 79 ha), moderately deep (max= 19 m), soft and acidic, and low in conductivity (50 to 130  $\mu\text{mhos.}$ ) Several of the deeper ponds have stable summer stratification; ice cover and winter stratification are usually intermittent.

Trophic condition is roughly inversely proportional to basin size, with some notable exceptions. Spring levels of total phosphate range from 5 to 30  $\mu\text{g liter}^{-1}$  with algal biomass (as chlorophyll a) from 5 to 30  $\text{mg m}^{-3}$ . Summer values range from 5 to 150  $\mu\text{g liter}^{-1}$  and up to 100  $\text{mg m}^{-3}$ , respectively. Secchi values range from 0.6 to 15 m in summer. Of the ponds that stratify in summer, several show extensive hypolimnetic anoxia, especially the largest, Gull Pond, which appears most affected by cultural eutrophication.

Profundal sediment strata are being analyzed for indications of water quality changes; estimates of phosphorus loading from septic tanks, gulls, and swimmers are also being made. These will determine appropriate management actions for preservation of the ponds.

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## LIMNOLOGY OF FOUR SMALL RESERVOIRS IN MISSISSIPPI

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Water resources for fishing, boating and water contact sports are an integral part of the majority of public parks. In this paper we report results of studies of small impoundments, especially as they are concerned with sports fishing.

Limnological features of four small reservoirs in Mississippi are compared. Weak thermal stratification was evident in the more shallow reservoirs, but normal sequence of fall overturn did not always occur. Waters are generally acid to slightly alkaline with a pH usually from 6.0 to 7.2 and conductivity is low and usually ranged from 8 to 73  $\mu$  mho/cm in the epilimnion. Zooplankton was dominated by the rotifers Keratella cochlearis, Polyarthra vulgaris and Trichocerca sp. and phytoplankton by the bluegreen algae Anabaena sp. and Oscillatoria sp. Shoreline development ranged from 1.6 to 4.3 and influenced the differences in biological production of the impoundments. Summer stagnation resulted in severe oxygen depletion in all of the reservoirs and reduced the total productive volume to the upper one or two m. Poor water quality and a lack of adequate fish shelter reduced fish production.

Subsequent information has shown that the addition of basic slag to increase pH, fertilization programs and construction of fish shelters appears to have improved catch results.

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IMPACT OF ACID DRAINAGE ON BENTHIC MACROINVERTEBRATE COMMUNITIES IN  
THE GREAT SMOKY MOUNTAINS NATIONAL PARK

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With the increasing visitor use of the Great Smoky Mountains National Park it was necessary to relocate U.S. Highway 441 in 1963. This management decision alleviated the problems caused by the influx of tourists although this reconstruction created new problems for the Great Smoky Mountains National Park.

The use of Anakeesta rock as road fill on Beech Flats Prong resulted in a severe reduction in biological stability of a once self-supporting trout stream. Assessment of the Anakeesta Leachate impact from July, 1975 to June, 1976 included analyses of physical-chemical and biological factors upstream of the road fill, immediately below the fill and 7 kilometers downstream from the fill. Monthly physical-chemical results of pH and phenolphthalein acidity reflect conditions that are highly acidic along with a substantial increase in sulfate, total hardness and conductivity values at the site directly below the Anakeesta fill as contrasted to the upstream reference and downstream recovery site.

Benthic macroinvertebrates were sampled monthly to characterize the biotic communities present at each site. Biological characterization using diversity, evenness, importance values and standing crop (number and weight) clearly indicate deterioration of the macroinvertebrate communities below the Anakeesta fill.

It is felt that both the physical-chemical and biological parameters measured are acting in aggregate to reduce the biotic stability of the macroinvertebrate communities present in Beech Flats Prong.

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ZOOGEOGRAPHY OF PLECOPTERA IN GLACIER NATIONAL PARK,  
MONTANA.

STANFORD, JACK A.

Taxonomic diversity of stoneflies (Insecta: Plecoptera) is extreme in the rivers, streams, and lakes of Glacier National Park, Montana. Over half of the 165 stonefly species known in the entire Rocky Mountain region inhabit aquatic environments in GNP. This remarkable diversity is a result of evolution in the heterogenous, but stable, environmental gradients which so characterize the streams and lakes of the area. Since three major river systems have headwaters in GNP (eg. Columbia, Missouri, Saskatchewan), the area may also be considered a zoogeographic 'melting pot' for aquatic insects.

Lotic habitats in GNP may be classified by occurrence of specific, dominant stonefly populations. Numbers of species decrease and closely related taxa are represented by different species in samples collected progressively from the rivers to the headwater streams. The North and Middle Forks of the Flathead River contain abundant populations Classenia sabulosa, Hesperoperla pacifica, Skwala paralella, Pteronarcella badia, Isocapnia spp. and Utacapnia spp. The larger tributary streams are characterized by populations of Doroneuria theodora, Megarcys watertoni, Kogotus modestus, and Capnia gracilacia. Setvena bradleyi, Capnia nana and Peltoperla brevis are most common in the small, cold headwater creeks. Streams emanating from springs may be characterized by the Zapada spp and other nemourids, Perlomyia utahensis and Megaleutra stigmata. Surprisingly, little species overlap occurs in these generally classified habitats.

Specific stonefly distributions in GNP and adjacent areas are a result of differing temperature and, to a lesser extent, habitat requirements. Thermal regimes in lower Camas and McDonald Creeks are warmed by lake discharges and their stonefly faunas do not conform to the proposed classification. They harbor river species.

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## AQUATIC INSECTS OF ASSATEAGUE ISLAND, VIRGINIA

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Ninety species of aquatic insects, belonging to 73 genera, are reported from the brackish water impoundments of Assateague Island, Virginia. Data are presented which reveal numerous facts about biology, habitat preference, seasonal movements and cyclic population changes of the more abundant species.

Many of the natural salt marshes and tidal flats on Assateague Island have been diked by dredging in order to create impoundments for migratory wildfowl sanctuary. These impoundments support a wide variety of fauna ranging from euryhaline to fresh water species. Aquatic insects can be found even in the more saline pools, along with such characteristically estuarine species as Callinectes sapidus Rathbun, the common blue crab.

Five aquatic insect species collected were new state records from Virginia.<sup>1</sup> These species are as follows: Ranatra australis Hungerford (Hemiptera: Nepidae), Haliphus confluentus Roberts (Coleoptera: Haliplidae), Hygrotus impressopunctatus (Schaller) (Coleoptera: Dytiscidae), Notomicrus nanulus (LeConte) (Coleoptera: Noteridae), and Paracymus nanus (Fall) (Coleoptera: Hydrophilidae).

The Virginia record of Hygrotus impressopunctatus (Schaller) represents a southern extension of its range. The Virginia record of the remaining 4 species represents northern extensions of their known ranges. The discovery of Notomicrus nanulus (LeConte) in Virginia is of particular interest because its previously known range in the United States was limited to Louisiana and Florida.

Two species of water boatman, Trichocorixa verticalis Fieber and Trichocorixa naias (Kirkaldy) both exhibited population peaks in June-July and November-December. The major peak occurred in June-July with the vast majority of T. verticalis Fieber exploiting open water habitat, while most of the T. naias (Kirkaldy) remained in shoreline habitat. The occurrence of larvae, teneral adults, and seasonal population peaks were observed for many of the other species collected.

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<sup>1</sup>Cross, J. L. 1972. New State Records of Aquatic Insects from Virginia. Proceedings of the Entomological Society of Washington, 74(4):476.

THE BENTHIC INVERTEBRATE COMMUNITY IN A LOGGED WATERSHED--REDWOOD CREEK, CALIFORNIA

AVERETT, R. C.,\* AND IWATSUBO, R. T.\*\*

Redwood Creek, northwestern California, drains part of the North American redwood forest--a unique ecosystem. The lowermost 17 miles of the drainage basin was designated as a part of Redwood National Park in 1968. The upslope area and contained tributaries, however, is privately owned and subjected to clear-cut logging. Benthic invertebrates in Redwood Creek and selected tributaries were sampled with a Surber one-square-foot sampler in the spring and autumn 1973-75 to evaluate the effects of logging on water quality.

Species diversity ( $\bar{d}$ ) never exceeded 4.0, and was highest in unlogged tributaries. Species evenness (J) varied widely, indicating no discernible pattern between tributaries in logged watersheds and those in unlogged watersheds. Similarity indexes (S) were commonly greater than 0.50, indicating a high similarity of organisms at all stations. Elmidae, especially *Optioservus* spp., and Hydropsychidae, especially *Hydropsyche* spp., were abundant in most samples. *Acroneturia* spp., a predacious Plecoptera, also were abundant in most samples. Dominant Ephemeroptera were *Baetis* spp., and *Rhithorgena* spp.

Between March 17 and 19, 1975, a storm released 7 to 13 inches of rain in the basin and increased the discharge in Redwood Creek from 6,000 cubic feet per second (ft<sup>3</sup>/s) to a peak of 50,200 ft<sup>3</sup>/s causing both scour and fill of mainstem and tributary channels. The scour and fill resulted in greatly reduced benthic invertebrate numbers in samples collected in May and June 1975. By September 1975, the number of species per sample was near pre-storm levels.

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AN ANALYSIS OF THE DISTRIBUTION AND ABUNDANCE OF BAETIS  
IN THE KAWEAH RIVER BASIN, CALIFORNIA

Abell, Dana L.

Winter collections of nymphs of the very common mayfly Baetis from the Kaweah River in and near Sequoia National Park indicate a gradient from low numbers to high along the lengths of the many branches. Anomalous high counts of Baetis are occasionally superimposed upon this gradient and are tentatively explained as indicative of an early phase in the recovery of the benthic community from an abrupt change in environmental conditions. Specific instances were the movement of a pulse of sand as bed load along a small stream, storm effects in a narrow gorge which was deficient in refuge sites, opening of snow cover by a prolonged mid-winter drought, a change from trickling to vigorous flow in a snowmelt tributary due to an extended thaw, and restoration of flow in a low elevation intermittent stream. Numbers of Baetis typically decline as species diversity is restored and numbers of other species increase. The phenomenon also appeared as a longitudinal community response to the abrupt emergence of ground water at springs, with Baetis being scarce in the spring itself, very common 20 meters downstream, and less common farther down the spring brook.

In these circumstances Baetis appears to offer some promise as an indicator of various types of recent environmental change. The range of such changes, including some caused or induced by man, remains to be explored. Different patterns of abundance in other seasons are likely and need study. Baetis may be particularly useful as an indicator due to its nearly ubiquitous occurrence, its major role in organic drift, and its amenability to simple sampling techniques.

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BASELINE STUDIES OF ISOLATED AQUATIC ECOSYSTEMS IN TWO  
ARID REGION NATIONAL PARKS

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Numerous isolated aquatic ecosystems in Big Bend and Guadalupe Mountains National Parks have been investigated to provide baseline limnological data by which detrimental ecosystem changes may be detected. From 1969 to present, several techniques have been used to measure such ecosystem parameters as benthic community structure including standing crop, trophic relationships, and seasonal cycles; benthic species diversity; secondary production; presence of "indicator" species; and general physical and chemical limnology.

Natural water quality varies considerably among the different ecosystems. Lower elevation streams, springs, and marshes are usually hard water systems while tinajas and higher elevation springs usually have lower concentrations of calcium and magnesium as well as other ions.

Thirteen collection sites in Big Bend produced 172 species of aquatic invertebrates representing 19 orders. Tornillo Creek alone produced 115 species from 17 orders. No one species was common to all sites. Larvae of baetid mayflies and chironomid midges were generally the dominant benthic animals. Less intensive sampling of McKittrick Creek, the only aquatic ecosystem in Guadalupe Mountains National Park, yielded over 45 taxa of aquatic animals including three species of fish. Twenty-three species of aquatic or aquatic-associated macrophytes were identified in McKittrick Canyon.

Benthic species diversity ( $\bar{d}$ ) ranged from 1.7 in a disturbed riffle in South McKittrick Creek to 4.0 in little disturbed North McKittrick Creek. Benthic species diversity in Tornillo Creek, Big Bend National Park, varied seasonally from 1.7 in December to 3.2 in April.

The isolation of these aquatic ecosystems is an important factor to the process of natural selection in those aquatic species with poor dispersal. Presence of relict populations supports the hypothesis of a retreat of montane environments both to the north and to the south. In Big Bend, two aquatic insect range extensions from the south and west are reported as is the presence of a new species of isopod. In McKittrick Creek, three aquatic insect range extensions from the north are reported.

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ESTUARINE NEKTON DIVERSITY IN THE VICINITY OF CUMBERLAND ISLAND NATIONAL SEASHORE, GEORGIA

ADAMS, PATRICK C.,<sup>1</sup> GREENE, ALBERT G., JR.,<sup>2</sup> AND REIMOLD, ROBERT J.<sup>1</sup>

Water quality criteria protect an important resource of our nation. Important species of organisms occupying coastal waters are frequently considered to be those that are commercially or recreationally valuable, rare or endangered, those that effect the well-being of some species either commercially or recreationally valuable or endangered, or organisms that are critical to the structure and function of the ecological system. A recent report from the National Academy of Sciences documents the importance of community structure and diversity studies in establishing baseline conditions. The report reveals that diversity indices summarizing large quantities of information regarding numbers and kinds of organisms have begun to replace the long descriptive lists common to earlier baseline environmental studies. Since community structure and diversity studies have an advantage over earlier techniques of comparisons between communities of organisms, a study was initiated to assess baseline conditions in estuaries adjacent to the Cumberland Island National Seashore, Georgia.

The nektonic diversity indices of estuarine organisms collected from 1970 through 1975 were computed on the basis of number of individuals as well as on the basis of wet weight biomass. Four indices of community diversities were computed: 1) Shannon-Wiener Index, 2) Index of Evenness, 3) Number of Moves Index, 4) Species Richness Index. Several factors were attributed to variations in diversity. These included niche size and overlap, succession, natural environmental stress, man-induced environmental stress (pollutants), productivity, competition, trophic structure of communities, and space. Resultant nekton diversity indices were found to be similar to those reported for other estuarine systems such as Galveston Bay, Texas, Duplin Estuary and Newport River, Georgia.

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## FISHES OF THE COLORADO RIVER IN GRAND CANYON NATIONAL PARK

SUTTKUS, R.D. AND CLEMMER, G.H.\*

Fish collections were obtained from thirty-five different sites along the Colorado River in Coconino and Mohave counties in Arizona from September 1970 through June 1976. Collection sites extended from Lee's Ferry (River Mile 0) to Pierce Ferry Landing on the south shore of Mead Reservoir (River Mile 280). A total of 112 collections yielded nineteen species of fishes, fifteen introduced forms and only four natives: the humpback chub, Gila cypha, speckled dace, Rhinichthys osculus, flannelmouth sucker, Catostomus latipinnis, and the bluehead sucker, Pantosteus discobolus. Three hybrids of C. latipinnis x Xyrauchen texanus, the humpback sucker, and at least one hybrid trout combination were taken.

Specimens of the endangered species, Gila cypha, were found at only five of the thirty-five locations sampled.

Distributions, population status, reproductive success, and associated complications imposed by introduced species, and the impact of man through modification are discussed.

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ENDANGERED SPECIES STUDIES ON THE YAMPA AND GREEN RIVERS IN  
DINOSAUR NATIONAL MONUMENT

SEETHALER, K. H., MCADA, C.W. AND WYDOSKI, R. S.

The continued survival of four rare fish species, the Colorado squawfish (Ptychocheilus lucius), humpback chub (Gila cypha), bonytail chub (Gila elegans), and humpback sucker (Xyrauchen texanus) is largely dependent upon the preservation of a natural river environment in the Yampa and Green Rivers within Dinosaur National Monument. In this report we discuss our studies on two of these species, the Colorado squawfish and humpback sucker.

The Yampa joins the Green at Echo Park within the Monument. Above Echo Park, the Green is so altered in temperature, flow, and other parameters by Flaming Gorge Dam, 65 miles upstream, that it no longer supports these species. The Utah Cooperative Fishery Research Unit has conducted investigations on these rivers since 1963.

In our current studies, beginning in 1974, we have intensively sampled the Green River below Echo Park and the Yampa River above. Our equipment consists primarily of trammel nets and seines. We have focused on age and growth, developmental stages, habitat preferences, movement, and ecology.

We have refined our knowledge on these issues and have documented that successful reproduction of endemic species has declined drastically in recent years. Reasons for the decline are discussed. Habitat preferences are further delineated, as are movement and behavior patterns. We have concluded that the Yampa is less vital in providing a place to spawn than in its influence on the Green through providing natural flows and temperatures which mitigate the effects of Flaming Gorge Dam. Our data has helped the Colorado Squawfish Recovery Team in defining "critical habitat" as specified in the Endangered Species Act of 1973.

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SPECIES RELATIONSHIPS AMONG FISHES OF THE GENUS GILA IN THE UPPER  
COLORADO RIVER DRAINAGE

SMITH, G. R., MILLER, R. R. AND SABLE, W. D. \*

Fishes of three species, the roundtail chub (Gila robusta), the bonytail chub (Gila elegans), and the humpback chub (Gila cypha), have been confused by recent workers. Because two of the species (cypha and elegans) are endangered, it is imperative that the relationships of the three species be understood and their identification be accurately determined in population evaluations and ecological studies.

Multivariate analysis shows these species to be clearly separate, but parallel evolution and allometric growth of the abrupt dorsal profile of two of these fishes, and occasional hybrids among them, have produced a gradation among key characters. New characters are incorporated in descriptions and keys given in this paper.

Gila robusta is the most widespread, least specialized, and least vulnerable species of the three. Gila elegans and G. cypha are most specialized in response to the hydrodynamically and trophically demanding environment of the Colorado Plateau drainage. They are also the species most vulnerable to cultural environmental change. An important refuge for these fishes is in the lower Yampa River, Colorado, a part of Dinosaur National Monument.

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REPRODUCTIVE ECOLOGY OF QUITOBAQUITO PUPFISH, ORGAN PIPE NAT. MON., AZ.

KYNARD, B. E.

The endemic Quitobaquito pupfish inhabit a spring-fed pool in the Lower Sonoran Desert Life-zone. It is the only population of Cyprinodon macularius that survives on protected public lands. This report examines several aspects of their breeding behavior, i.e., seasonal timing, diurnal variation in spawning, and habitat selection in relation to physico-chemical factors.

During the spring of 1975 and 1976 reproduction began at water temperatures of approximately 25°C (April or May). During 1975, breeding ceased in August. The number of reproductively mature fish in June of 1976 was determined to be 2800 using the Peterson Estimate. Sex ratio did not differ significantly from 50:50.

Territorial males remained on their defended space both day and night. Males were not active during darkness but resumed reproductive activity at dawn or when daytime water temperatures warmed to approximately 25°C.

Early in the breeding season, males occupied small territories along the pond's edge in shallow water (<25cm) and in deeper offshore water over dense mats of Chara sp. and Potamogeton sp.. Later this distribution changed and males no longer occupied areas in dense vegetation. This change seemed related to warmer nighttime temperatures and a corresponding low dissolved oxygen in those areas. Data from field habitat-choice experiments revealed a distinct preference for shallow water (<10cm) by territorial males.

It is concluded that these pupfish do not utilize the deeper waters of the pool for breeding and that only a relatively small portion of the total bottom area is suitable for spawning.

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THE CURRENT STATUS OF GAMBUSIA GAIGEI, AN ENDANGERED FISH EN-  
DEMIC TO THE BIG BEND NATIONAL PARK

WILLIAMS, J.G.

Frederick H. Gaige first reported the presence of the Big Bend Mosquito-  
fish in 1928. Since that time the existence of the species has been  
severely threatened on several occasions by natural occurrences, the  
introduction of competitors and inadvertent neglect. This paper is a re-  
port on the joint efforts undertaken through the years by the National  
Park Service and University Of Texas personnel to preserve this endan-  
gered species. The past history of the taxon is related, the present  
status is described and the plans for the future are presented.

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## POST GLACIAL DISPERSION AND PRESENT DISTRIBUTION OF SALMONID FISHES IN THE NORTHERN CASCADES RANGE

WASEM, C. R.

For recreational and commercial fishing, salmonids are the most important group of fishes in coastal and inland waters of the Pacific Northwest. Ancestral salmonids probably evolved in shallow saline seas and extensive freshwater lakes of northern Asia and North America beginning with late Oligocene or Miocene times. Later during the Quaternary Period climatic changes to cooler more moist conditions resulted in extensive continental and alpine glaciation in the newly-uplifted northern Cascades Range and adjacent Puget Trough and Okanogan Highlands.

Ancient fishes retreated before the advancing Cordilleran ice sheet and valley glaciers, found refuge in unglaciated areas to the south, west, and east, and reinvaded former glaciated regions as ice masses retreated during the several warm interglaciation periods.

With the end of Pleistocene glaciation fishes reinvaded main stream drainages penetrating deeply into the mountain mass. Extensive ice erosion of the recently uplifted Cascade Range created low-gradient U-shaped valleys with steep side slopes and hanging tributary valleys with cirque basins at their heads. Few migration barriers in low elevation main drainages permitted access to salmonids with eventual establishment of resident and anadromous populations. However, fish could not gain access to the steep tributary streams or to the numerous cirque lakes because of physical barriers. This situation persisted until the end of the 19th century when Caucasian man began fish cultural activities and extensive introductions of exotic and native strains of salmon, trout, and charr for purposes of recreation and commercial harvest. Today few waters of the northern Cascades Range remain biologically pristine.

North Cascades National Park  
Sedro Woolley, Washington

SEGREGATION OF THE NATIVE EASTERN BROOK TROUT (SALVELINUS FONTINALIS)  
AND INTRODUCED RAINBOW TROUT (SALMO GAIARDNERI) IN THE GREAT SMOKY  
MOUNTAINS NATIONAL PARK

TRUMPF, W.F., AND MORGAN, E.L.

Taywa Creek and Tennessee Branch in the Great Smoky Mountains National Park was selected for investigations into possible physical, chemical and biological factors causing the segregation of Rainbow Trout (inhabit the lower stream sections) with the Eastern Brook Trout (occupying the upper head waters).

Physical-chemical analyses consisted of phenolphthalein acidity, pH, total hardness, total alkalinity, sulfates and conductivity. Biological characterization involved analysis of benthic macroinvertebrate community structure using diversity, evenness, importance values and standing crop (number and weight). Habitat characterization included establishing pool-riffle ratios, stream cover and gradient for each of the trout populations inhabiting the same drainage.

Information thus far suggests that the physical-chemical and biological parameters measured are not important factors causing the segregation of the two trout species. Possible separating mechanisms including competition for food resources are discussed.

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AGE-GROWTH RELATIONSHIPS OF BROOK TROUT (SALVELINUS FONTINALIS) AND  
RAINBOW TROUT (SALMO GAIRDNERI) IN COSBY CREEK, GREAT SMOKY MOUNTAINS  
NATIONAL PARK

HOFF, MICHAEL H., AND MORGAN, ERIC L.

The decline of natural populations of brook trout (Salvelinus fontinalis) in the Great Smoky Mountains National Park has led to the initiation of an intense study of this species. Up until this time very little life history information has been generated on the brook trout in the Park. Therefore, it was the intent of this study to estimate the age-growth relationships of brook trout in a stream of the Great Smoky Mountains. Cosby Creek was selected as a study site since this stream is known to have sections containing only brook trout, a nearly equitable mixture of rainbow trout (Salmo gairdneri) and brook trout, along with a section numerically dominated by rainbow trout. The rates of growth of brook trout in each of these areas are examined while the growth rates of both species are compared.

Back-calculation and aging of brook trout was achieved using vertebral sections since scale annuli were found to be indiscernible. However, rainbow trout were aged using both scales and vertebral sections.

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THE ENVIRONMENT OF SOUTH FLORIDA, A SUMMARY REPORT. PHASE I,  
THE DEPARTMENT OF THE INTERIOR'S CONTRIBUTION TO THE SOUTH  
FLORIDA ENVIRONMENTAL STUDY.

McPHERSON, B. F.

The original south Florida ecosystem has given way to a new three-part ecosystem which incorporates an agricultural component, an urban component, and a component of the original ecosystem that is largely undeveloped but still has been affected by man. These components, are interrelated through the flow of energy and resources.

Man has altered the ecosystem of south Florida extensively for 70 years. About 35 percent (3,000 square miles) of the original habitat of the ecosystem has been destroyed by agriculture or urbanization. The remaining natural habitat is threatened by exotic plants and animals, altered water levels and flows, severe fires, pollution, loss of animal and plant populations, and by further growth and development.

Man's most dramatic and long-term effects on the ecosystem have resulted from drainage. Wetlands originally occupied about 75 percent of south Florida; through the years much of this land has been drained. In southeast Florida, for example, drainage has lowered water levels 5 to 6 feet below the 1900 level and stressed natural systems.

Water is a key environmental factor in that it not only affects a system directly, but that it affects other controlling environmental factors such as fire, soil, temperature, and salt penetration. Water is also a key factor manipulated by man.

Agricultural and urban systems require fresh water to sustain them and thus compete with the remaining natural systems. The present difficulty in water supply is linked to urban demands which require increasing diversions of water from the natural and agricultural systems.

U.S. Geological Survey  
Water Resources Division  
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LANDSAT DATA: A TOOL APPLIED TO  
WATER MANAGEMENT IN SOUTH FLORIDA

HIGER, A. L.

Landsat data from South Florida were categorized into vegetation-water depth classes. Imagery from both wet (19 October 1974) and dry (3 March 1975) periods were processed. The vegetation-water depth classes delineated relate directly to surface water depth in Conservation Area 3A, a water management area within the Everglades. Water depths from eight data collection platforms within Area 3A and thirteen water-level stations in Everglades National Park, and Landsat multispectral reflectance from digital tapes were computer processed to determine the water depth for each Landsat picture element in Conservation Area 3A. With the October data, nine water depths, from 0.1 to 3.0 ft, were determined. The area of each water depth was tabulated and an estimate of the total volume of surface water (in acre-ft.) within Conservation Area 3A was reported for each date. When compared with the estimates made by a polygon technique (U. S. Army Corps of Engineers), the Landsat derived estimates were less by as much as twenty percent. Surfaces of the conservation area above water level (such as tree islands) are removed from the estimates with the Landsat technique but not with the polygon technique.

U.S. Geological Survey  
Water Resources Division  
Miami, Florida

ESTUARINE AND COASTAL MARINE FISHERY MANAGEMENT IN EVERGLADES NATIONAL PARK

DAVIS, GARY E.

Fishery harvest is the only natural resource consuming activity permitted by policy in National Parks. This policy requires precise management of Park ecosystems while they support fishing mortality in addition to natural mortality if they are to continue to function as natural systems.

In this paper I report the development and operation of a monitoring program for a mixed commercial and recreational fishery in Everglades National Park.

The National Park Service commitment to fishery management in south Florida was first stated formally in 1936, and a policy to manage for a "sustained yield" established in 1959. Supported by modest Park Service grants for ten years, from 1958 to 1969, University of Miami scientists conducted interviews with recreational fishermen and conducted investigations into the life histories of popular sportfish. Based on this work a comprehensive program to monitor park fishery harvest and fishery stocks was developed.

The present Everglades National Park fishery monitoring program utilizes catch, fishing effort and length frequency data collected with daily trip reports from professional guides and commercial fishermen, and dockside interviews with recreational fishermen. Total boating and fishing activity are estimated from aerial surveys and daily counts of boat trailers at launching ramps. These data are used to estimate total harvest of 22 species of estuarine and coastal marine fish and shell fish from six ecologically different areas in the park. The availability of fishery species, measured as catch per unit of fishing effort, is being used to monitor and assess the effects of watershed management and environmental conditions on fishery resources.

During each of the last three years about 250 commercial fishermen and more than 150,000 recreational fishermen harvested 1.5 million kilograms of fishery resources from a 3000 km<sup>2</sup> area in Everglades National Park. With the exception of the stone crab fishery, none of the park fisheries shows evidence of overfishing at this time. However, the effects of disrupted fresh water flow into park estuaries and below normal rainfall was reflected by increased abundance of mature gamefish in traditionally hyposaline nursery areas.

Implementation of this fishery monitoring program is only the first step in managing the fishery resources of the park. This information must now be integrated with an environmental monitoring program and applied to maintain a dynamic balance between fishing mortality and the requirements of naturally functioning ecosystems.

Everglades National Park  
Homestead, Florida 33030

SEASONAL BIOMASS ESTIMATES OF MARINE AND ESTUARINE FISHES WITHIN THE  
WESTERN FLORIDA BAY PORTION OF EVERGLADES NATIONAL PARK, MAY, 1973 TO  
JULY, 1974

SCHMIDT, THOMAS W.

An investigation of the macro-invertebrates and fish fauna of Florida Bay was initiated in order to acquire ecological base line information on the absolute abundance (standing crops of fishes) and relative abundance of marine and estuarine biota.

This study represents the first time that measures of biomass (wet weight) estimates on a monthly basis by habitat were utilized to determine the distribution of marine and estuarine fishes in Florida.

Estimates of the fish populations (Kg/h) in western Florida Bay were obtained monthly at eight seine sites from May, 1973, to July, 1974, and four otter trawl stations from October, 1973, to July, 1974. The area of each sample site was measured by square meters and represented an ecologically unique marine habitat.

A total of 95,344 fishes, representing 109 species and 45 families were taken in seines and the otter trawl. Their total biomass was 293.3 kilograms.

Numerically and by biomass the dominant species in the regular catches were anchovies, primarily the striped anchovy Anchoa hepsetus. Excluding the anchovies, the most abundant by number were goldspotted killifish Floridichthys carpio, silver jenny Eucinostomus gula, rainwater killifish Lucania parva, and pinfish Lagodon rhomboides.

Biomass data provides a more even assessment of the ecological role of a particular organism in respect to the overall composition of fish populations and accordingly reveals more ecological information than numerical data.

By biomass, the dominant species were southern stingray Dasyatis americana, lemon shark Negaprion brevirostris, silver jenny, pinfish, and mullets (Mugil cephalus and M. trichodon).

In conclusion, the distribution of the fishes in western Florida Bay were quantitatively related to habitat preferences and the cyclic nature of the hydroperiod.

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DISTRIBUTION AND ABUNDANCE OF MARINE MAMMALS IN THE WATERS OF THE  
EVERGLADES NATIONAL PARK

ODELL, D. K.

Aerial surveys to document the distribution and abundance of the bottlenose dolphin (Tursiops truncatus) and the West Indian manatee (Trichechus manatus) were conducted in the waters of the Everglades National Park (Florida: U.S.A.) between September 1973 and June 1976.

Each survey flight was made over a similar flight path at an altitude of 305 m (1000 ft) and at an air speed of 177 kph (110 mph). The aircraft was a Lake LA-4 and at least two observers (pilot included) were on board for each flight.

Forty-eight (48) flights were completed for a total of 120 survey hours and 21,144 air survey kilometers (13,135 miles). Mean survey time per flight was 2.5 hr and the mean air distance surveyed per flight was 460 km (286 miles). A total of 565 dolphin herds (1601 individuals) and 306 manatee herds (797 individuals) were seen. Survey effort is best summarized as animals seen per survey kilometer. For dolphins this was 0.027 herds/km and 0.076 animals/km. For manatees it was 0.015 herds/km and 0.038 animals/km. The effectiveness of a particular survey in sighting animals depended on many factors. Most important were the weather just before and during the flight, and the sea surface and turbidity conditions resulting from this weather. The best conditions were a mirror flat sea surface with a high overcast sky preceded by several days of calm weather. Statistical treatment of the data is hampered by the present inability to quantify the effects of these and other variables on the probability of sighting an animal.

Most of the dolphins and manatees were found from Whitewater Bay northward to the northwestern Park boundary, including the inland waters. Dolphin abundance in the Park waters was considerably higher than that found in southeastern Florida waters (Biscayne Bay and vicinity). The reasons for the differences are unclear.

Other marine mammals observed in the Park were a dead fin whale (Balaenoptera physalus) and a dead sperm whale (Physeter macrocephalus).

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III. GEOLOGY

THE ROLE OF ECOLOGICAL AND GEOLOGICAL RESEARCH IN THE MANAGEMENT OF COASTAL PARKS.

Godfrey, Paul J.

Over the past decade, research in the fields of ecology and geology has been significant in providing options for the management of National Seashores along the East Coast. The basic ecological and geological mechanisms by which barrier beaches, (mostly those on the Outer Banks of North Carolina), respond to storms and rising sea level was more clearly documented, and this information was put to use by Park Service managers. The majority of this research was supported by the National Park Service; the information gained has also been used widely by other agencies and has even led to new fields of research. Without this work, few management alternatives would have been available, and past mistakes might have been repeated.

Further work on the ecology of coastal barriers has shown that not all systems work exactly the same way; northern and southern areas are particularly different. It is essential that each system be analyzed individually and compared to others. One solution to a particular management problem cannot be applied to all areas. It is important that comparative studies be made of the basic mechanisms which create these coastal areas (dune building, inlets, overwash, rising sea level, waves, storms, and biological responses).

NPS Cooperative Research Units, such as those now existing at several universities, can provide a continuing source of data on both long and short term problems, and thus maintain necessary continuity in research. Projects of the UMass CRU now underway at Cape Cod National Seashore will be used as an example of this potential.

It has become clear that proper management of coastal parks, and all parks, must build on basic research elucidating natural processes; it is likewise important that research programs be shaped to the needs of park management.

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## GEOMORPHIC STUDIES IN SOME WESTERN NATIONAL PARKS AND MONUMENTS

SCHUMM, S. A.

Geomorphology is the science of the landscape and its dynamics; it is the study of landforms and the erosional and depositional processes that have formed them and the rates at which the processes act. Most western National Parks and Monuments are areas of unique scenic beauty and geomorphic interest. They are areas that have been protected from man-induced changes, and, therefore, the National Parks and Monuments can provide geomorphic information over long periods on the natural evolution of the landscape.

Geomorphic investigations in the National Parks and Monuments have produced and they will continue to produce important scientific results that, in addition, can be used by the National Park Service for educational purposes. Examples of past and current geomorphic research will be discussed as follows:

- Badlands National Monument - slope and pediment evolution
- Chaco Canyon National Monument - slope failure and mass movement
- Arches National Monument and Canyonlands National Park - rock weathering
- Scotts Bluff National Monument - river morphology and river adjustment
- Great Sand Dunes National Monument - dune migration and open-channel hydraulics (pulsating flow).

These examples of geomorphic research demonstrate clearly that the National Parks and Monuments are a national scientific resource that can and should be utilized to increase our understanding of landforms. This understanding, in turn, can be used to enhance the enjoyment and awareness of visitors to these areas.

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THE INFLUENCE OF PRESCRIBED FIRE ON WATER-REPELLENCY OF  
MIXED-CONIFER FOREST FLOOR

AGEE, J.K.

Prescribed fires are becoming a useful means of restoring the natural role of fire to national park ecosystems. The hydrologic impacts of such burning have not been intensively studied, and particular concern has been voiced about intensification of in situ soil water repellency after fire.

Several prescribed fires were applied to mixed-conifer forest sites under varying weather conditions. Before burning, water-repellent characteristics of the forest litter and soil were high. Under the low intensity fire prescriptions applied, fire influenced water-repellent characteristics of the litter more than the soil. A simulated rainfall was applied before and after burning, and retention was influenced more by amount of litter than by water-repellency of litter or soil. A simplified model of erosion hazard from natural or prescribed fires was developed from a precursor model, and indicated that a prescribed fire program could operate without generating significant erosion hazards.

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## GEOHYDROLOGY OF THE BUFFALO RIVER BASIN AND RELATED LAND USE PROBLEMS

HURLEY, S. C.

By act of Congress 1972, the Buffalo River became a National River under the auspices of the National Park Service. Information on the hydrologic system, the geology of the area, land use, and potential environmental problems in the Buffalo area are included in this report.

Rocks underlying the Buffalo River basin range in age from Precambrian to early Pennsylvanian. The sedimentary section is approximately 5,000 feet thick and is composed mainly of limestone, dolomite, sandstone and shale. The strata are essentially horizontal and structural deformation is minimal.

The aquifers are considered in two parts: the shallow and the deep aquifer system, however, both are under artesian pressure and the piezometric surfaces of each coincide. The shallow aquifers are recharged by precipitation falling directly within the basin and the ground water moves from the higher elevation down the hydrodynamic gradient where it is discharged into the effluent streams. In contrast to the shallow aquifers, the deep aquifers receive most of their recharge outside of the Buffalo basin where they crop out in southern Missouri. Water moves south down the hydrodynamic gradient into northern Arkansas.

Ground water quantities in the shallow aquifers are relatively low in yield, but are sufficient for domestic use. Because carbonate rocks make up much of the sedimentary section, the occurrence of ground water is largely dependent on secondary openings such as interconnected fractures and solution channels. Wells encountering secondary openings are generally fortuitous. The deep aquifers, the Roubidoux Formation and the Gunter Member of the Gasconade Formation are the most reliable aquifers in the basin, yielding 55 and 250 gallons per minute, respectively.

The Buffalo River is highly variable deriving much of its flow from direct overland runoff. The capacity of geologic formations to store and yield water to streams is small. Periods of low-flow (ground water discharge) occur most frequently in the late summer and fall, whereas maximum streamflows occur most often in winter and spring.

A land use map of the existing land use patterns (1972-1973) is included. An adequate inventory of the existing land use conditions of the basin is necessary in order to help explain current environmental phenomena, and to preclude or minimize environmental problems brought on by future land use changes.

Exxon Company, U.S.A.  
New Orleans, Louisiana 70161

INVESTIGATION OF RADIATION PRODUCED BY RADON AND THORON IN NATURAL  
CAVES ADMINISTERED BY THE NATIONAL PARK SERVICE

\*YARBOROUGH, DR. KEITH A., PRINCIPAL INVESTIGATOR; \*\*AHLSTRAND,  
DR. GARY A.; \*FLETCHER, DR. MILFORD R.; \*\*\*MCGOWN, MR. JOSEPH;;  
\*\*FRY, MRS. PATTY

The National Park Service (NPS) has studied levels of alpha radiation in all NPS administered caves. This radiation is produced by the radioactive decay of Radon and Thoron gases, which in turn result from Uranium and Thorium decay. These latter elements are found in all terrestrial rocks and soils, in varying though minute concentrations. The decay products of the two noble gases which constitute a potential health hazard are their short-lived "daughters". These are ionized solids which may become attached to dust and water particles in cave air. When inhaled into the lungs they can cause radiation damage which can lead to lung cancer after prolonged exposures, because the radiation has large ionizing effects on lung tissues. Continuous exposures of many years usually are necessary before atypical cells appear. This has been documented to be anomalously high among uranium miners. Smoking has a contributory effect which greatly increases the radiation health hazard.

Radiation levels are measured by the "working level" (WL). One WL is defined as any combination of Radon daughters in 1 liter of air which will result in the ultimate emission of  $1.3 \times 10^5$  MeV of potential alpha energy. The value of the WL is derived from the alpha energy released by the total decay of short-lived daughters in equilibrium with 100 pCi of Rn-222 per liter of air or of 8 pCi of Thoron per liter. The report gives WL ranges for NPS caves.

Cumulative exposure is measured by the working level month (WLM), defined as the exposure received from breathing air at one WL concentration for 173 working hours per month (40 hrs./work wk.).

Radiation Health standards are set by several government agencies: Mining Enforcement and Safety Administration, National Institute for Occupational Safety and Health, EPA and OSHA. The NPS research has the dual but complementary objectives: 1): To safeguard health at the NPS administered caves; 2). To develop data on alpha radiation levels and on natural airflows in caves. The results reported for NPS caves can be used by various agencies to clarify health standards for exposures to lower radiation levels in cave environments. These results show daily and seasonal trends and the influence of natural ventilation by air circulation for each cave investigated. Epidemiological test results are reported, also.

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ARSENIC AND ANTIMONY IN GEOTHERMAL WATERS OF YELLOWSTONE NATIONAL  
PARK

STAUFFER, R.E.,\* AND THOMPSON, J.M.

A total of 260 Yellowstone thermal spring samples were analyzed for total soluble As using reduced molybdenum-blue; 23 of these samples were also analyzed for total Sb using flame atomic absorption spectrometry. All easily accessible thermal basins were sampled.

Total soluble As ranged from 7.89 at Joseph Coats to  $< 0.014$  mg/l at Washburn. Low As contents were associated with condensed vapor springs ( $Cl < 10$  mg/l). The Cl/As atomic ratio was nearly constant among neutral-alkaline springs with  $Cl > 100$  mg/l, and within restricted geographic areas, indicating no differential effects of adiabatic vs. conductive cooling on soluble As. The Cl/As ratio decreases with decreasing  $Cl/\Sigma CO_3$ ; the relationship is best exemplified for springs along the extensively sampled SE-NW trend within the Upper Basin. The relationship between Cl/As and  $Cl/\Sigma CO_3$  indicates a rock leaching rather than magmatic origin for much of the total As flux. Very high Cl/As ratios ( $> 1000$ ) were associated exclusively with highly diluted ( $Cl < 100$  mg/l) mixed springs in the Shoshone Basin and in the Upper White Creek and Firehole Lake areas of Lower Basin. The high ratios may indicate precipitation of As following massive dilution of the As-bearing high-Cl parent water.

Soluble Sb ranged from 9 at Mammoth to  $166 \mu\text{g/l}$  at Joseph Coats Spring. Within basins, the Cl/Sb ratio increases as the  $Cl/\Sigma CO_3$  ratio decreases, in marked contrast to As. Mixed springs also have elevated Cl/Sb ratios. White and Weissberg have previously reported that stibnite ( $Sb_2S_3$ ), but not orpiment ( $As_2S_3$ ), precipitates in the near surface zone of some alkaline geothermal systems.

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ALUMINUM PRECIPITATION, BEECH FLATS AND WALKER'S PRONG CREEKS,  
GREAT SMOKY MOUNTAINS NATIONAL PARK

\*Herrmann, R. and \*\*Morgan, E. L.

Oxidation and hydrolysis of disseminated iron sulphide minerals within the Anakeesta Formation, a pre-Cambrian meta-sedimentary unit has been observed to produce sulphuric acid runoff at outcrops both natural and factitious. Acid ground and surface waters dissolve and transport relatively large quantities of aluminum and magnesium and lesser quantities of copper and zinc. Iron is selectively precipitated, under these conditions, near the outcropping resistate materials, while aluminum exhibits increased solubility and is precipitated downstream as aluminum hydroxide. A probable geochemical model of this occurrence is proposed. A sequence of aqueous oxidation-reduction reactions, having established equilibrium constants, are the result of weathering processes operating on pyrite and feldspar minerals contained within exposed rock materials.

Environmental fluctuations cause re-solution and/or colloidal suspension of aluminum hydroxide precipitate, increasing stream distances over which this effect can be noted. This increased mobility of aluminum places significant stress upon the lotic macroinvertebrate communities and the native brook trout (*Salvelinus fontinalis* Mitchell) population. Synergistic toxicity of copper and zinc is suspected, however, the existing concentrations of aluminum are sufficient to account for the observed population shifts.

Documentation of these geochemical processes are significant in that minor perturbations resulting from fresh exposure of bed-rock materials are shown to profoundly alter existing aquatic ecosystems. Geochemical instabilities similar to these are common in nature and are predictable.

Within the limits of this study, the geochemical processes and biological responses can be equated to those noted in other areas. Direct parallels may be drawn that will result through design changes or relocation of projects in the preservation of the environmental integrity of similarly threatened primitive "natural" streams.

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EVIDENCE OF A FAIRLY RAPID CHANGE IN WATER LEVEL OF NAKNEK LAKE,  
KATMAI NATIONAL MONUMENT, ALASKA, SHORTLY AFTER THE  
ERUPTION OF 1912

DENNIS, JOHN G.

Naknek Lake, one of three, major, glacially formed lakes at the base of the Alaska Peninsula, is approximately 64 km long, 10 km wide, and has a surface area of about 610 km<sup>2</sup>. Reconnaissance sampling indicates that, at the time of the 1912 eruption of Mt.s Katmai and Novarupta, the lake level was probably 0.5-1.0 m higher than at present, and that the water level dropped fairly rapidly within a few years after the eruption. Because Naknek Lake is and probably will remain a major facet of the Monument's transportation and visitor development system, knowledge of the cause of and possibility of reoccurrence of this apparent change in lake level will benefit Park Service planning for future development and use of the Monument.

Naknek Lake traditionally has undergone seasonal changes in lake level of as much as 1.5 m, with low water occurring in late winter and high water occurring in the fall. At Brooks Camp during the late 1960's, high water reportedly lapped over the berm at the upper edge of the present beach. In 1974, the high water reached no higher than about 0.5 m below the base of this berm, and the upper two thirds of the recently exposed beach was being colonized by scattered individuals of nine plant species. At each of three sample points along the Naknek Lake shoreline (Bay of Islands, Research Bay, and Brooks Camp), the present vegetation nearest the probable water line of the late 1960's either is treeless or contains trees that in 1974 were less than about 60 years old. At each sample site it is possible to find portions of a former shore where presumably wave-borne sand and pumice pebbles overlie an ash layer deposited by the 1912 eruption. The highest measured point where sand (in this case mixed with the organic duff) overlay ash was nearly 2.5 m above the late August, 1974 water level.

Possible causes of the one, and perhaps two, recent drops in water level indicated by the data reported here include: 1) a short term or more permanent change in the regional precipitation regime, 2) a change in the water balance of the headwater glaciers in the Aleutian Range, 3) an episode of more rapid downcutting of the bed of Naknek River where the river cuts through the terminal moraine that has created Naknek Lake, and 4) an earthquake-induced shift in the elevation of that river bed. More detailed studies will be needed to determine the actual cause of these apparent drops of lake level, to determine whether such water level changes may be reversible, and to determine whether such changes occur frequently enough to become a consideration for the design and operation of future visitor facilities and activities.

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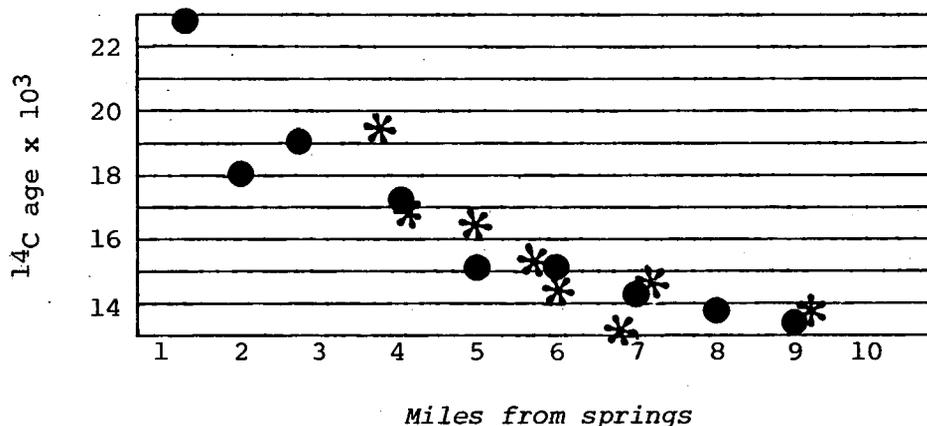
HAVASU CANYON - A NATURAL GEOCHEMICAL LABORATORY

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Havasu Canyon, Arizona, serves as a natural geochemical laboratory in which we are trying to isolate and quantify the factors that contribute to the demonstrated unreliability of radiocarbon dates of calcareous tufa. Geologic studies of the tufa itself and of the interbedded alluvial sediment have identified a sequence of well-dated changes in regimen of the stream that occupies the canyon.

Havasu Creek rises from perennial springs and falls 1,500' in the course of 10 miles of flow to the Colorado River. Local turbulence around bed and bank obstructions drives off CO<sub>2</sub>, triggering precipitation of CaCO<sub>3</sub>. Riverside trees fall into the creek, become coated with CaCO<sub>3</sub>, and are incorporated into growing tufa structures. We have acquired radiocarbon ages for the outermost wood and innermost tufa of very young tufa-encrusted wood samples. The difference between the wood date and the tufa date for each sample is a crude measure of the disequilibrium at the sample site between the <sup>14</sup>C/<sup>12</sup>C ratio in the atmosphere (from which the wood C is derived) and the <sup>14</sup>C/<sup>12</sup>C ratio in the water (from which the tufa precipitated) at the time the tree died. We have also obtained radiocarbon ages of CaCO<sub>3</sub> currently being precipitated as encrustations on living vegetation suspended in the water:

● = contemporary-tufa age \* = wood/tufa disequilibrium value



Equilibration of carbon-isotope ratios between Havasu Creek water and the atmosphere is proceeding, but is far from complete at the mouth of the creek. Calcareous tufa precipitated at spring orifices and/or from stream water should not be used for radiocarbon analysis unless the accuracy of such ages is established by other means.

Havasu Creek is partially incised into a thick column of alluvial sediment capped by a veneer of calcareous tufa. The sediment was deposited during a period, beginning about 3,000 years ago, when overland runoff contributed more to total discharge of Havasu Creek than it does today. The tufa caprock represents first approach to modern conditions of water chemistry about 900 years ago. The spectacular waterfalls along Havasu Creek have developed during the contemporary incision. Along much of the creek, the present profile was established 400 years ago; rapid adjustment is still in progress near Beaver Falls.

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## HYDROLOGY OF THE MAMMOTH CAVE NATIONAL PARK AREA AND ITS RELEVANCE TO PARK AND REGIONAL PLANNING

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Although the Central Kentucky Karst has long been studied, knowledge of its regional groundwater hydrology, with a few local exceptions, has been largely a matter of speculation based on interpretation of piezometric maps, other well data, and a few caves. A systematic dye-tracing and cave mapping program has demonstrated the relations between the dozens of sinking streams south and east of Mammoth Cave National Park, the numerous springs along the Green, Barren, and Little Barren Rivers, and the caves between the uplands and these rivers.

Cave streams, some of which carry pollutants, have been traced as much as 24 km. The recharge area of major springs has been determined and groundwater basins have thus been delineated. Major caves have been mapped and much has been learned about the plumbing system of the upper part of the principal aquifer. Most groundwater moves by conduit flow rather than diffuse flow. Trunk conduits are commonly as much as 15 m wide; water levels in them fluctuate as much as 30 m in response to storms. Dendritic groundwater flow-patterns have been established. Six spring systems have been shown to have a distributary complex as much as 50 m to 4 km wide. Water quality of springs, wells, and streams has been studied. Structural and stratigraphic controls on groundwater movement have been recognized. All of this work is still in progress.

The knowledge thus gained is relevant not only to interpretation of the park and surrounding region but, perhaps more importantly, it is essential for park planning, resources protection, regional sewage disposal, and industrial development.

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# PHOSPHORUS IN GEOTHERMAL WATERS OF YELLOWSTONE NATIONAL PARK

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Previous investigators have reported  $\text{PO}_4\text{-P}$  levels of order 1 mg/l in Yellowstone geothermal waters. However, these analyses were biased by interferences from high As contents ranging from 1-3 mg/l in the Yellowstone hot spring waters.

We analyzed 97 Yellowstone hot spring and geyser samples (field acidified to  $\text{pH} < 1.4$  with  $\text{HCl}$  or  $\text{HNO}_3$ ) for  $\text{PO}_4\text{-P}$  using reduced molybdenum-blue and the selective arsenate reducing agent, meta-bisulfite-thiosulfate.

The  $\text{PO}_4\text{-P}$  concentrations found ranged from below detection limit ( $\sim 1 \mu\text{g/l}$ ) to  $73 \mu\text{g/l}$ . Twenty-five springs had  $\text{PO}_4\text{-P}$  concentrations exceeding  $6.8 \mu\text{g/l}$ ; seven spring samples exceeded  $20 \mu\text{g/l}$ . Elevated  $\text{PO}_4\text{-P}$  contents were invariably associated with mixed springs, as evidenced by diluted Cl concentrations, and frequently, sub-boiling temperatures, low pH's, and elevated Ca concentrations. Alkaline high-Cl ( $>400 \text{ mg/l Cl}$ ) geothermal waters from Upper and Norris Geyser Basins had  $\text{PO}_4\text{-P}$  concentrations below  $2 \mu\text{g/l}$ , and represent the low end of the range of  $\text{PO}_4\text{-P}$  contents in natural waters. Statistically no significant difference was found between total P and soluble reactive P for the hot spring waters.

Thermodynamic calculations indicate that in the Upper Geyser Basin equilibrium with fluorapatite ( $\text{Ca}_5(\text{PO}_4)_3\text{F}$ ) controls  $\text{PO}_4$  contents.

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STRATIGRAPHY AND MICROFOSSILS OF THE PRECAMBRIAN ALTYN  
FORMATION OF GLACIER NATIONAL PARK, MONTANA.

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The Altyn Formation belongs to the lower part of the Precambrian Belt Supergroup and it is the oldest sedimentary rock unit exposed in Glacier National Park. The rocks were deposited 1400 to 1500 million years ago in a re-entrant on the west coast of a Precambrian continent. The Altyn Formation is composed of dolomites and sandy dolomites and contains abundant primary sedimentary structures, stromatolites and rare microfossils.

The rocks range from fine-grained dolomicrites to coarse dolarenites composed of peloids, intraclasts and occasional ooids. Detrital grains of quartz and microcline occur throughout the Altyn Formation and they are abundant at some horizons.

Primary sedimentary features present in the Altyn Formation include current and wave formed ripple marks, planar crossbeds, intraformational breccias and conglomerates, desiccation cracks, channels, algal mats, branched and unbranched columnar stromatolites, collapse microbreccias and pseudomorphs after evaporites.

Black cherts occur infrequently in the Altyn Formation but some of them contain well preserved filamentous and coccoidal microfossils. Most of the microfossils are believed to belong to the cyanophycean families Oscillatoriaceae and Chroococcaceae, although other forms of uncertain affinities also occur.

The Altyn Formation was deposited in marine shallow subtidal to intertidal and supratidal environments where blue-green algae flourished. Progradation of tidal flats into a shallow sea produced shoaling upward cycles of sedimentation and created conditions suitable for the formation of dolomite and other evaporite minerals.

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PALEOECOLOGY OF THE PALEOCENE BLACK PEAKS FORMATION, BIG BEND  
NATIONAL PARK, TEXAS

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The fauna of the Black Peaks Formation is the southernmost large Paleocene mammalian fauna of North America. It contains 29 species of mammals belonging to 28 genera. Three exposures of the 170-meter (560-foot) thick, fluvial formation are known, and all three lie within Big Bend National Park.

The formation was deposited by meandering rivers; the climate in the region was semitropical to tropical with alternating wet and dry periods of greater than seasonal duration. In the wet periods, water from floods lingered, and dark, marshy, acid layers of alluvium containing organic matter formed. In the dry periods, flood-deposited alluvium dried out and was oxidized to form carbonate-nodule-rich red layers.

Comparison of the Black Peaks southern fauna and the well-known northern faunas of similar ages, such as those from Wyoming and Montana, reveals geographical variations. The occurrence of the multituberculate Ectypodus musculus in the Black Peaks Formation strengthens the theory that it was a southern animal, and the occurrence of the pantodont Titanoides indicates that it is not restricted to northern localities as it was previously considered to be. Species unique to the Black Peaks fauna include a barylambdid pantodont, a multituberculate, and an insectivore. A specimen of the primitive perissodactyl Hyracotherium angustidens, ancestor of the horse, is only the third Hyracotherium yet to be reported from rocks older than the Eocene.

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SIDE-LOOKING AIRBORNE RADAR (SLAR) IMAGE ANALYSIS OF DEATH VALLEY,  
CALIFORNIA

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By grey tone differences, side-looking airborne radar (SLAR) images of the saltpan and alluvial fans on the floor of Death Valley show variations in backscatter or echo strength which correlate with very small scale changes in surface roughness. The SLAR image data have enabled us to: (1) distinguish subtle differences in gravel sizes on alluvial fans, (2) computer process a digitized 3 cm wavelength radar image of the Cottonball Basin and produce a contour map of 0-80 cm scale vertical and horizontal surface roughness, and (3) detect several previously unmapped geologically young faults. Low altitude panchromatic and color photographs, Skylab and Landsat multispectral photographs/images, and computer enhanced Landsat images do not contain comparable information.

The above results were accomplished by analyses of synthetic aperture SLAR image data generated by the USAF Strategic Air Command (using the Goodyear Aerospace Corp. 3 cm wavelength system) and the Jet Propulsion Laboratory 25 cm wavelength system. The 3 cm (X-band) wavelength system incorporated depression angles of 11° for far range and 49° for near range. The original image scale was 1:480,000 and resolution in range and azimuth was approximately 15 m. The 25 cm wavelength (L-band) system is unique in that it is capable of imaging through depression angles ranging from 90° to 45°, producing a surface elevation profile at aircraft nadir. Current resolution in range for this system is approximately 60 m while azimuthal resolution at all angles is about 20 m. Original image scale was 1:600,000.

Empirical radar scattering models for the diverse surfaces of the Death Valley saltpan are currently being developed using accurate in situ measurements of the probability size frequency distribution of surface irregularities. These data were obtained in concert with measurements of surface/subsurface moisture content and dielectric constant values during April 1976 multipolarization, multifrequency (X- and L-bands) SLAR overflights of the valley. This unusually well calibrated radar investigation is being conducted as a joint venture by the U.S. Geological Survey and the Jet Propulsion Laboratory. From these and earlier data sets we plan to produce surface roughness maps for the entire floor of Death Valley at the centimetre scale. Project support for the U.S. Geological Survey is from the NASA Planetology Program Office (contract W13, 576) and for JPL from NASA contract NAS7-100.

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PALEOECOLOGY OF PETRIFIED WOODS FROM THE AMETHYST MOUNTAIN "FOSSIL FOREST", YELLOWSTONE NATIONAL PARK, WYOMING

FRITZ, WILLIAM J. AND FISK, LANNY H.

Fossil woods from the classic Yellowstone "Fossil Forest" have been studied to better interpret the paleoecology and depositional history of the individual "forests". Our results indicate that the previous interpretation of distinct forests buried in situ is somewhat lacking. The case for alternate interpretations will be given.

The Amethyst Mountain area in Yellowstone National Park contains a unique "Fossil Forest" consisting of more than 27 levels of upright petrified stumps and horizontal logs entombed in a volcanic ash and breccia matrix. Study of fossil leaves, needles, pollen and spores from the Eocene "forests" have shown that a wide range of plant types representing cool temperate to tropical climates can be found on a single level. This heterogeneous mixture is difficult to explain for individual "forests" preserved in situ unless considerable transportation of some plant organs has occurred. The most obvious interpretation, that presented by most previous workers, is that tropical-subtropical trees grew in the valleys of deposition and the cool temperate floral elements were transported in from the nearby highlands by the intense rain showers and resultant flooding associated with the volcanic eruptions. Of the several species of petrified wood thus far described, however, temperate trees were predominate. These wood samples were collected from stream beds or the scree at the base of the mountain with no attempt made to assign them to their original stratigraphic levels or to individual stumps. The purpose of this study was to sample stumps and logs in individual units in order to better interpret the paleoecology of the "forests" at the depositional site.

The woods of 56 stumps and logs on "Fossil Tree Level 21" have been collected and thin sectioned. Of the woods thus far identified, temperate trees, such as Pinus and Sequoia are still dominates. However, it appears that some tropical-subtropical dicotyledonous woods may be represented. It has been found that 50% of the trees are in a horizontal position, a much larger percentage than previously thought. The remaining 28 trees include 24 vertical stumps and 4 which are diagonal.

The precise stratigraphic control and quantitative data available from this study is providing better paleoecological interpretations than have been previously available. Data analysed to date seem to indicate 1) that the climate at the depositional site was temperate and the warmer climatic indicators have been transported in, presumably to a higher sedimentary basin, 2) that the climate of the sedimentary basin was tropical-subtropical as previously suspected and the temperate indicators (including upright stumps) are allochthonous, 3) that most or all of the various climatic indicators have been washed in and perhaps none were actually growing at the depositional site, or 4) that the Eocene plants did not grow under climatic conditions similar to their living counterparts and thus no paleoclimatic conclusions are justified. In any regards, it appears that it is time to re-examine the evidence in hand and continue to dig for additional evidence in search for the correct paleoecological interpretation for Yellowstone's "Fossil Forest". In the meantime, investigators should continue to use multiple working hypotheses.

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REINVESTIGATIONS OF THE PETRIFIED FORESTS OF YELLOWSTONE NATIONAL PARK,  
WYOMING AND MONTANA

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The Eocene "fossil forests" of Yellowstone National Park and vicinity are famous for their abundance of well preserved plant remains, particularly the numerous superposed layers of upright petrified stumps. Yet, these deposits have not been extensively investigated and many have not even been examined by paleobotanists. Detailed study and description of the complete flora and entombing sediments are in progress and are beginning to cast doubt on some previous interpretations. This paper will present a progress report of recent investigations of the paleobotanical, stratigraphical, and sedimentological evidence and document the need for alternate interpretations.

Since their discovery almost 100 years ago, Yellowstone's "Fossil Forest" has attracted considerable popular attention but surprisingly little detailed investigation. Understandably, the current popularized picture of 27 distinct forests which were buried in situ by subaerial volcanic mudflows is an oversimplification. Further work on the paleoflora (particularly pollen, spores, and wood) has revealed a high taxonomic diversity and ecologic heterogeneity which is difficult to explain for forests supposedly in position of growth. Such a mixed assemblage is characteristic of other Paleogene floras of North America and is probably best explained by transport to the depositional basin of plant parts from several different environments. Alternately, one could conclude that the fossil taxa did not have climatic tolerances similar to their living relatives (in which case no paleoclimatic interpretations would be possible).

Detailed stratigraphic sections of the best exposures have shown that at some localities there are 40 to 50 superimposed levels of upright stumps. The discontinuous nature of some of these stratigraphic units and the depositional features of the volcanoclastic sediments suggest that not all of these layers of upright stumps represent in situ forests. Our investigations indicate instead that at least some of the vertical stumps are allochthonous and may have been deposited on a fresh-water deltaic plain where they were entombed by either subaerial or subaqueous debris flows (volcanic lahars).

The nature of the accumulating evidence should cause one to have caution in drawing paleoecological interpretations of the petrified stumps and logs comprising Yellowstone's petrified forests. The complexity of the depositional environment, only partially recognized by previous investigators, has been greatly re-enforced by these reinvestigations.

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## COASTAL PARAMETERS RELATIVE TO HARBOR DESIGN

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Baseline coastal geologic and biologic data gathered over a years period is applied to the problem of proper placement and construction of a harbor facility in the Apostle Islands National Lakeshore Park of Lake Superior, Wisconsin. Consideration has been given to both onshore and offshore processes with bearing upon the environmental impact of shore based engineering structures.

Changes in beach morphology were relative to the yearly beach cycle with areas of concentrated cut and fill related to engineering obstructions. Existing structures altered the nearshore sedimentation patterns by alteration of wave induced currents. A prevailing eastward current was found to range from 0 to 18.3 cm/sec due to a dominant and prevailing northwest wave attack. Fluorescent tracer and stake field analysis showed the nearshore sedimentation to be controlled by these wave induced currents. In general, nearshore wave energy distribution was related to the relative openness or protection of the shoreline, while artificially altered by the existing structures.

Analysis of the above factors suggested that the harbor facility should consist of an impermeable breakwater, placed beyond the area of observed sediment motion (greater than 10 foot depth) and oriented so as to offer protection from dominant northwesterly storm waves. The breakwater should be shore connected by a wooden piling supported walkway with a minimum piling spacing of 3 feet to allow passage of the longshore current and associated drift. This permeable shore attachment should allow sufficient wave energy in the more active shallow waters to prevent shoaling in the anchorage area and alleviate the need for dredging and beach nourishment.

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CASE HISTORY OF A COASTAL INVESTIGATION AT THE CAPE COD NATIONAL SEASHORE

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During 1964, shortly after the establishment of the Cape Cod National Seashore, an investigation of the Bruun theory of sea-level rise as a cause of shore erosion was conducted at Herring Cove and Nauset Light beaches. The results of the investigation established the validity of the concept, and the theory is now an accepted part of the coastal literature.

Bruun held that when an equilibrium profile was developed, (1) there was a shoreward displacement of the beach profile as the beach was eroded; (2) the material eroded from the upper beach was equal in volume to the material deposited on the nearshore bottom; (3) the rise of the nearshore bottom as a result of this deposition was equal to the rise in sea-level, thus maintaining a constant water depth in that area.

In the field investigation, the variation between neap and spring tide was utilized as a short-term model of sea-level rise in obtaining profiles on the two dissimilar beaches. Scuba gear and a newly devised profiling technique were employed to obtain precise control. First-order determinations affirmed the predictability of shore erosion following a rise in sea-level.

In the intervening years since publication of these findings, the theory, dubbed BRUUN'S RULE, has found general acceptance among coastal specialists. The conclusions, stemming from the Cape Cod National Seashore study, have been cited in the well-known texts of King and Bird; in Fisher's field guide to the geology of The Cape Cod National Seashore; and in the coastal literature by Swift, Dubois, and others.

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BEACH DYNAMICS AND MANAGEMENT PROBLEMS OF SANDY HOOK SPIT, GATEWAY  
RECREATION AREA

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Our paper describes an applied research program aimed at the establishment of guidelines for the management of beach resources within the Gateway National Recreation Area, Sandy Hook Unit. The goal of the research is to minimize the destructive effects of storms and long-term erosion through implementation of beach protection measures which are compatible with the goals of the National Recreation Area. Once the mechanisms and quantities of sediment movement are identified, appropriate beach management strategies will be selected.

To this end, hydrodynamic process and morphologic response data for sample beaches representative of each spit segment are being gathered in a 40-day time series, during the winter storm season. Additional sand movement data, provided by tracer and trap studies, will be correlated with the wave processes to define the dynamics of the spit.

A computer simulation model is also being developed that, calibrated with the local data, will refract a given wave train to the breakpoint, calculate sediment transfers, and transpose this into beach form changes. Moreover, it will be capable of evaluating the physical impacts of various beach management options.

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## ASSATEAGUE ISLAND: A CASE STUDY OF BARRIER ISLAND DYNAMICS

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The northern portion of Assateague Island, Maryland is presently experiencing severe erosion, and overwash processes are active along this 5 mile stretch of coastline. The short-term sedimentary dynamics of a washover area were quantified by monthly as well as pre- and post-storm surveying of the washover fan and adjacent environments at 5 sites along the island. The long-term importance of overwash processes were determined by comparison of historical aerial photography.

After 26 months and 7 discrete overwash events, there has not been any backbarrier accretion (landward of the primary dune line). In fact, there has been a slight loss of material at each washover area. The prevailing northwest wind eroded the newly-deposited overwash material, transporting the majority of the sand back to the beach. Therefore, there exists a balance between overwash and eolian processes with wind transport slightly dominant.

Since the long-term perspective was needed to make a true assessment of the geological implications of this process, remote sensing was the logical choice. Inspection of historical aerial photographs demonstrated that the areas of rapid landward migration and greatest island widths were associated with inlet dynamics. By incorporating all shore data, it appears that the overwash process, at maximum transport capability, is only effective in maintaining the island as a low, barren barrier. The island's width is allowed to fluctuate within the limits of 400 to 700 feet as the barrier is translocated landward. Inlet breaching and subsequent flood tidal delta formation is viewed as the only mechanism by which the island can exceed the 700 foot width limitation, consistent with an eroding shoreline.

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INTERACTIONS OF PLANT COMMUNITIES AND OCEANIC OVERWASH ON THE  
MANIPULATED BARRIER ISLANDS OF CAPE HATTERAS NATIONAL SEASHORE, NORTH  
CAROLINA

Travis, Richard and Paul J. Godfrey

The ecological effects of oceanic overwash on barrier islands have only recently received attention. A study was begun in 1973 at Cape Hatteras National Seashore to determine the impact of overwash on the dune and barrier flat vegetation that has grown up as a result of stabilization programs. Plant communities that have developed on and behind the artificial barrier dunes are different from vegetation that was present before the dunes were built. These communities also differ from natural vegetation on barrier islands north and south of Cape Hatteras.

The vegetation of Cape Hatteras National Seashore has not, however, lost its ability to recover from overwash in a short time. Observations will be presented that describe how *Spartina patens*, the principal member of the grassland community behind barrier dunes, responds to depth, season, and method of overwash burial. This research suggests that most of the vegetation in, around, and behind barrier dunes in this Seashore will recover when the dunes are finally broken down and overwash occurs again. The presence of the existing vegetation will moderate overwash events, and sand carried onto the island will soon be revegetated. As the man-made dunes break down, new dunes will form on overwash deposits, and the barrier islands of this Seashore will take on a more natural pattern of retreat as sea level rises. It appears that overwash events will not seriously damage or change the ecology of Cape Hatteras National Seashore.

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VEGETATION AND STRATIGRAPHY OF CORE BANKS, CAPE LOOKOUT NATIONAL SEASHORE, N. C., IN COMPARISON WITH NORTHERN BARRIER BEACHES

Godfrey, Paul J., Melinda Godfrey, Richard Nathhorst and Bronwen Fullington

A detailed survey was made of the stratigraphy of Core Banks, North Carolina, coring along a series of six transects; elevation and vegetation data were also taken along each. The vegetation at each coring site was analyzed for frequency and cover. Piston cores and vegetation transects were made on Nauset Beach, Cape Cod National Seashore, Massachusetts, for comparative data.

The coring data showed conclusively that Core Banks is a typical overwash structure, made up of beach sediments deposited during overwash events. Beneath all sections of the barrier island, salt marsh peat or bay bottom sediments were found. The vegetation associated with each area of relatively recent overwash, and the most common grassland community on Core Banks, is dominated by *Spartina patens*. Scattered low dunes have *Uniola paniculata* as the dominant grass.

Coring data from Nauset Beach showed that this barrier spit has had overwash, and is retreating over marshes in a similar manner to Core Banks, but rather than being a low flat barrier, Nauset Beach has a high, relatively continuous dune line. The vegetation on the dune here is dominated by *Ammophila breviligulata*; *Spartina patens* occurs only at the edge of the salt marsh. Overwash events kill the *Spartina* vegetation in the North; in the South the same species pushes up through the sediments. In the North, overwash sites are colonized by dune species which regenerate from drift lines carried in during the overwash. On Core Banks, the overwash is colonized by *Spartina* pushing up from buried vegetation. These different ecological responses, with a lessened frequency of overwash in the North and a better dune-building environment, may account in part for the differing physiography of southern and northern barrier beaches.

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BARRIER ISLAND STUDIES, MISSISSIPPI-ALABAMA GULF COAST

OTVOS, ERVIN G., JR.

Landform feature and preliminary, detailed drill core data from six islands indicated their varied history. (Five are or will become part of the National Seashore.) Four islands consist of stable, broad core areas with attached, less stable, low spits. Cat Island represents four ridge generations. Some of the islands probably originated by shoal-aggradation, others by sand-veneering of preexisting ridges ("composite type").

Stratigraphic interpretations were based on combined color, texture, consolidation, and paleontological sediment data. Bright colors are rare in buried Pleistocene surface sediments. Eastern Dauphin Island consists of limonite- and humate-impregnated Late Pleistocene deposits, covered by Holocene sands. A 7700±820 yrs B.P. date (UGa-1266) is from subrecently contaminated Late Pleistocene humate, precipitated during a lower sea level stand. Under the Ship Islands, the earliest extant Mid-Holocene transgressive unit is 5.5-9.0 m thick, unconsolidated, brackish, muddy deposit, overlain by 7.5-10.0 m thick nearshore-shoal sands. 6-8 m thick muddy deposits underlie 10.5-12 m of partly silty sands beneath eastern Horn Island. Despite frequent 0.5-1.25 tons/sq ft penetrometer values, the age of the muddy unit is probably also Holocene.

The Holocene evolution of the study area was influenced by the positions of Pleistocene barrier ridges, the Mississippi-St. Bernard subdeltas, and the westward littoral drift. Barrier island genesis through spit-segmentation is denied by the limiting effect of tidal flow. A "mainland-ridge engulfment" origin is equally unlikely. Earlier Holocene deposits under the Mississippi Sound include foraminifer faunas, generally more saline than those found in the most recent Sound sediments.

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RESULTS OF BEACH NOURISHMENT USING DREDGED MATERIAL, FORT MASSACHUSETTS, GULF ISLANDS NATIONAL SEASHORE, MISSISSIPPI

HENRY, V.J.

During March, 1974, the U.S. Army Corps of Engineers placed approximately 400,000 cubic meters of material from maintenance dredging of Ship Island Pass along a 1.5 kilometer segment of eroding shoreline on the western end of Ship Island, Mississippi. The project was requested by the National Park Service for the protection of Fort Massachusetts acquired in 1971 as part of the Gulf Islands National Seashore.

During the 28 month monitoring period following nourishment the shoreline and offshore portions of the fill area have undergone relatively rapid adjustment to seasonal conditions of winds, waves and currents. Greatest net change has occurred along the eastern one third of the beach which has retreated over 80 meters. The shoreline change along the central and western segments of the fill area have tended to straighten the original irregularities with a maximum retreat of 35 meters. Much of the material eroded from these segments has been deposited along the western tip of the island and the area immediately adjacent to Ship Island Pass where prevailing westerly longshore drift moves sediment into Ship Island Pass Channel and forms an ephemeral northwest-trending spit.

Bathymetric changes also have occurred in the nearshore areas. The movement of material away from the beach by cut and fill processes has caused shoaling which progressively decreases toward the edge of the shallow shelf.

During the initial 22 month period following nourishment the shoreline retreated an average of 1.3 m/month; the eastern portion at a rate of 2.6 m/month and the western portion at a rate of 0.1 m/month. The most rapid and severe changes in the fill shoreline have occurred during winter "northers" which are rapidly moving cold fronts with over 80 km/hr northwesterly winds.

Because the fill shoreline is now within 12 m of the Fort, serious consideration must be given to additional nourishment prior to the onset of the winter storm season as well as to the longterm economic and environmental feasibility of the project.

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ACTIVE GEOLOGIC PROCESSES PADRE ISLAND NATIONAL SEASHORE - IMPACT ON  
PARK MANAGEMENT

MATHEWSON, CHRISTOPHER C.

The Padre Island National Seashore in South Texas came into existence when Congress authorized its purchase in 1962. Padre Island is one of the barrier islands along the Texas coast, and stretches from Corpus Christi to Brownsville. The Island in the seashore is characterized by a nearly continuous foredune ridge, as much as 10-12m high, behind a beach about 200m wide. Behind the foredune ridge a vegetated flat, grassland, slopes gently into Laguna Madre. Occasionally the flats are crossed by large 600m wide by 2km long active dune fields. In Laguna Madre numerous channels have been dredged for oil and gas platforms and the Gulf Intracoastal Waterway. Much of the National Seashore is passible only to 4 wheel drive vehicles, limited to the beach, or shallow draft boats limited to Laguna Madre.

In addition to the need for Park development the Park Service faces the problem of protecting the environment and providing for the recovery of oil and gas resources. As part of a Sea Grant project with additional support from the National Park Service and Sun Oil Company a three year study of the active geologic processes was made.

The active processes can be subdivided into: 1) aeolian processes and 2) hydraulic processes. The aeolian processes are responsible for the large unstable dune fields and the movement of sand across the Island. In terms of Park Management, these processes can lead to the destruction of roads and improvements by sand burial. Once the stable foredune ridge is breached, either by roads and paths or by hurricane processes, a dune field can form. In Laguna Madre hydraulic processes lead to the siltation of dredge channels or the rapid erosion of dredge material islands. The islands that resist erosion and become vegetated were observed to play an important ecological role by providing protected nesting places for numerous shorebirds. Dredge Material island erosion rates and sediment distribution patterns are a function of : 1) wind tides, 2) prevailing and storm winds, 3) water depth, and 4) location of the island.

Park management decisions can be greatly enhanced once the active geologic processes are known.

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PANEL DISCUSSION: RESEARCH IN THE NATIONAL PARKS

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PANELISTS: BARNETT, JOHN, JR. AND \*HERRMANN, RAY

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PANEL DISCUSSION - NO ABSTRACTS SUBMITTED

## GLACIAL GEOLOGY OF RECENTLY DEGLACIATED BEDROCK AREAS

Hallet, B.

Areas recently exposed by the retreat of cirque glaciers in Glacier National Park, Montana, were studied, in the context of the modern glacier sliding theory, to elucidate the processes that are active at the bases of these glaciers. This study can be subdivided into three parts: subglacial chemical exchange; striations and basal ice flow; and roughness of glacier beds and calculated sliding velocity.

Thin coatings of calcite, formed by subglacial precipitation of  $\text{CaCO}_3$ , patchily cover most of the areas uncovered by the retreat of each of four glaciers visited, and are particularly well developed below the Blackfoot Glacier. The subglacial concentration and precipitation of solutes are intimately related to basal sliding; on one hand solutes concentrate because of the sliding process, and on the other, the sliding velocity may be slowed by solutes because of their effect on the thermal regime of the basal temperate ice (Hallet, 1976, Geol. Soc. America, V. 87, p. 1003-1015).

Striation patterns indicate that minor bed irregularities often cause major deviations in the basal ice flow. They also occasionally reveal circulating, eddy-like flows above bedrock concavities, suggesting that basal flow and sliding may be considerably more complicated than generally recognized.

Lastly, the roughnesses of glacier beds were analyzed quantitatively because they control the sliding velocity. Spectral analyses of a topographic profile surveyed near the Grinnell Glacier suggest that theoretically the glacier ought to slide less than one meter per year. In view of measured surface velocities of about 15 m/year near the terminus, the theory appears to underestimate the sliding velocity.

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OBSERVATIONS OF GLACIER VARIATIONS IN GLACIER BAY  
NATIONAL MONUMENT

FIELD, W. O.

The major changes in the glaciers are known since Muir's visit in 1879 and in considerable detail since Reid's observations in 1890 and 1892. Glacial geologists and geobotanists have worked out the chronology and sequence of events during the last few thousand years. Our own observations were begun in 1926. In the last two decades the various programs of observation have been stimulated by the valuable support and encouragement of the National Park Service.

Glacier Bay offers unusual opportunities for research because of (a) the variety of glacier types, (b) the magnitude of the changes, (c) the long record of observations and the three dimensional data available, and (d) the presence since the 1930's of both advancing and receding glaciers. Some explanations for the seemingly paradoxical behavior of the glaciers are now emerging and will be discussed.

Glacier Bay is not only an excellent laboratory for the study of contemporary phenomena, but also provides clues to a better understanding of many of the processes of glaciation. Continuation of the present programs are recommended with additional emphasis on geophysical studies, including marine geology, oceanography, high level observations in the snowfields, and the climatic environment.

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## GLACIER FLUCTUATIONS IN GLACIER BAY, ALASKA, IN THE PAST 11,000 YEARS

McKENZIE, G. D.

As the Wisconsin glaciation waned in Alaska, the ice margin retreated from the Pacific Ocean through Icy Strait and northwest into Glacier Bay. In eastern Adams Inlet, 75 km from Icy Strait, glaciomarine clays rest on Wisconsin till, and peat at the top of the clay records invasion of grasses, sedges, and ferns about 11,000 years BP. Extent of retreat of glaciers at this time in other areas of Glacier Bay is uncertain, but during Hypsithermal time (7000 to 4000 years BP), when the climate was slightly warmer than now, most termini were probably behind present positions.

As glaciers retreated into valleys tributary to inlets of Glacier Bay, outwash areas became extensive. Valley filling by gravels continued through the Hypsithermal. In eastern Glacier Bay, gravels were deposited in Wachusett Inlet, 9 m above present sea level, 7000 years BP; in Adams Inlet, 3 m above sea level, 3700 years BP; and at Forest Creek, 60 m and 75 m above present sea level, at 2100 and 1800 years BP, respectively.  $^{14}\text{C}$  dates on buried stumps indicate that about 4100 years BP deposition of lake sediments began in Muir Inlet, and that 1700 years BP a lake formed in Adams Inlet, dammed by outwash in Muir Inlet and later by Muir Glacier or Russell Glacier.

Neoglacial advance of the Muir Glacier system is recorded at Wachusett Inlet 2735 years BP; at White Thunder Ridge 2120 years BP, and in Adams Inlet 1700 years BP. Neoglacial ice (Russell or Reid Glacier) in western Glacier Bay advanced in Reid Inlet about 4700 years ago. Till on the south side of Geikie Inlet records ice there 1540 years BP; if this till was not deposited by Russell Glacier, this glacier was probably nearby. Maximum extent of Early Neoglacial ice in Glacier Bay is unknown. Retreat during Neoglacial time in Glacier Bay is recorded in Adams Inlet, where deposits have been preserved that show a retreat and still-stand of ice in the Inlet, probably in response to the retreat of the Russell Glacier north of the entrance to Muir Inlet. This retreat occurred about the time of the Little Optimum (AD 1150 to AD 1300). A similar fluctuation has been recorded for Brady Glacier.

By about AD 1700, ice in Glacier Bay reached its maximum Neoglacial extent near Bartlett Cove. Detailed observations of the rapid retreat of the Russell and Muir systems have been made since 1890. The total Neoglacial retreat has been over 100 km, at an average rate of about  $400 \text{ m a}^{-1}$ .

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RESULTS OF EIGHTEEN YEARS OF RESEARCH BY THE INSTITUTE OF POLAR STUDIES  
IN GLACIER BAY NATIONAL MONUMENT, ALASKA

GOLDTHWAIT, R. P. AND MCKENZIE, G. D.

Research by members of the Institute of Polar Studies has yielded important results in glaciology, glacial geology, and to a lesser extent, biology. Institute field parties have operated regularly, since 1958, in most parts of Glacier Bay National Monument, an area that provides a unique opportunity to study a diversity of phenomena.

Glaciological research has included measurement of variations in glacier velocity and calving, mass balance, heat balance, and rates and mechanisms of basal movement. On a stagnating remnant, ice structures exhibited variations in flow directions between Neoglacial and present ice, flow rates were lower with elevation, stream-flows were proportional to melt, and meltwater storage occurred with water table in intercrystalline fractures and larger shear planes in the upper few meters. Basal till deposition rates were 0.4 to 2.8 cm yr<sup>-1</sup>. Ablation rates near several termini range from 6 to 9 m yr<sup>-1</sup>. Genesis of glacier caves and drainage mechanisms of ice-dammed lakes have been studied.

Glacial geomorphological observations suggested that backwasting of stagnant masses is more important than downwasting, based upon marginal channels, till fabrics, crag-and-tail features, and kames defining such dwindling ice masses. Mechanisms of development of many geomorphic features were determined; rates for such features include 1 to 5 summers for minor moraines, 1 to 2 years for marginal channels, 1 to 5 years for large eskers, and 1 to 5 m per century for outwash build-up.

The record of glacial history in the Monument begins with Illinoian (?) till south of Lituya Bay, where some raised marine terraces and an ice-free refugium are older than 170,000 years. Central Glacier Bay shows isostatic marine conditions up to 60 m about 11,000 years ago, following Wisconsin retreat. Hypsithermal time, when temperatures were higher than today, featured valleys emerging and filling with outwash. About 2700 BP the Early Neoglacial advance reached Muir Inlet. Less than 1000 years ago the Late Neoglacial, with temperatures 2°C lower than today, brought readvances which climaxed at Lituya Bay 400 years ago and at Bartlett Cove 200 years ago. Rapid retreat of over 100 km followed, and repeat of isostatic uplift goes on at rates up to 4 cm yr<sup>-1</sup> today.

Metabolic studies of plants, ice-worm ecology, distribution of plants and animals, and ecological succession cover some of the biological programs. In the past 18 years, 61 scientists, on 25 projects valued at more than a quarter of a million dollars, have reported their results in more than 40 publications. These results have been used in interpretive studies and Monument management.

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## AEOLIAN THEORY REEXAMINED FOR THE WHITE RIVER GROUP

Harksen, J. C.<sup>1</sup>, Olson, D. K.<sup>2</sup>, and Gordon, E. A.<sup>3</sup>

The South Dakota Geological Survey has recently begun an extensive study of the stratigraphy and depositional environments of the Oligocene White River Group, concentrating primarily on the Brule Formation, within and immediately surrounding the Badlands National Monument. These studies are intimating that aeolian deposition played a much greater role than has been previously believed by most workers.

Early geologists, who first studied the Tertiary formations of the Great Plains, formulated the theory that the sediments were deposited in great fresh water lakes. This theory was upheld until the turn of the century, when both aeolian and fluvial theories were presented to replace the lacustrine theory. The fluvial theory for White River deposition was well presented in a paper by J. B. Hatcher (1902) and since that time only minor objections have been raised.

We have found that the general lack of coarse channel sediments, overall sediment size, geographic area of exposure, absence of well defined fluvial characteristics, and massiveness of the unit suggest wind as a primary depositing agent for the sediments. This study lends credence to the work of W. D. Matthew (1901), who originally proposed and documented an aeolian source for the White River Group of Colorado.

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## GENESIS OF THE EROSIONAL FORMS OF BRYCE CANYON NATIONAL PARK

LINDQUIST, R.C.

No detailed studies exist on the character of the escarpment or the origin of the unusual erosional forms found in Bryce Canyon National Park. These forms have generally been attributed to differential weathering and erosion along the vertical joints present throughout the Wasatch Formation. Studies conducted during the past three summers indicate that, while the joints may be involved when favorably oriented, they do not appear to be a necessary condition for wall formation.

The primary conditions of formation involve the nature of the slope processes, the gulying process of scarp retreat, and the lithology of the Wasatch Formation. Variations in the conditions, plus those of relief and degree of penetration of the Wasatch Formation lead to a division of the escarpment into three sections of different characteristics based on those conditions.

The erosional forms may originate in several possible ways and a division based on the mode of origin and resulting configuration has been formulated. The divisions include those formed on the escarpment headwall by gully incision and/or jointing, walls weathered from ridge crests located at a distance from the scarp, ridge slope forms not directly associated with gulying, and residual forms.

Other unreported features were also found during these investigations. The carbonate of a number of beds was found to be predominantly or entirely dolomite rather than limestone. Also four faults were found in the main amphitheater section of the Park with two of the faults representing structural controls of the rim in the Bryce Point area.

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## QUATERNARY AND HOLOCENE LAKES IN ZION NATIONAL PARK, UTAH

Hamilton, W. L.

At the present only three lakes are known in Zion. These are intermittently dry, less than a few acres in size, and they are due to recent rockslide damming of intermittent canyon streams. It is of interest then that shoreline and lake bed deposits have been found indicating the existence of at least eight major lakes in the canyons of Zion during late Quaternary and Holocene times. Separate stages are recorded for some of the larger lakes which, at maximum extent, ranged in size from about 0.5 to about 10 square miles.

The Holocene lakes were caused by slump block and slide dams. Older lakes were produced by lava damming, augmented in some cases by slides. The close association of volcanic rocks, lake deposits, and slide debris suggests that elevated water tables may have contributed to block slumping of the canyon walls in the case of lava-dammed lakes. Alternatively, earthquakes associated with volcanism may have been responsible for triggering mass movements. Climatic enhancement of stream discharge is considered to have been a contributing, but not a causative, factor.

Relatively rich fossil remains are preserved in some of the lake sections. Fossils include a track of a camel, a track of a large bird, a vertebra tentatively identified as belonging to a bison, various insect tracks, shells of gastropods and bivalves, plant parts, and pollen grains. Other materials are being identified.

A late stage in the life of Sentinal Slide Lake in Zion Canyon has been dated at 3600  $\pm$  400 years B.P. by radiocarbon dating of plant carbon.

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FLUVIAL REGIME OF THE COLORADO RIVER IN THE GRAND CANYON  
AND ITS MODIFICATION BY GLEN CANYON DAM

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Prior to 1963 the Colorado River was little affected by man. The river's regime was characterized by spring floods from snowmelt and periods of heavy suspended-sediment loads during summer runoff. Regulation of the river by the Glen Canyon Dam has reduced peak flows resulting in sediment-free water most of the year. The responses to this change have been assessed by field surveys and by photogrammetric analyses.

Three size ranges of sediment were worked by the river prior to the dam. Flash floods of high gradient tributaries deposited alluvial fans of boulders, often exceeding a meter in size, into the river. These deposits constricted the river and produced steep rapids. With lower postdam peak flows and, therefore, lower competency the fan debris is no longer moved. Tributary floods are steepening some of the rapids, causing navigation hazards.

Because cobble bars and banks deposited by predam flood flows along the wider portions of the river valley cannot be transported by postdam flows, the cobble bars are not changing.

Silt and sand were deposited in slack water by predam floods, particularly in back eddies below the rapids. Our measurements indicate that the postdam regime is scouring these sand banks. Many terraces above present high water have been altered by wind, side-canyon runoff, and human impact. The result is a gradual diminishing of the number of sandy terraces suitable for camping.

An apparent net deposition of fine-grained sediment has occurred in the canyon. Since channel width has increased, this sediment has either been deposited on the bed of the river, perhaps filling in predam scour holes, accumulated behind steeper postdam rapids, or removed from the river by overbank sedimentation.

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WINDTHROWS AND CRADLE KNOLLS IN THE BIG THICKET NATIONAL PRESERVE,  
SOUTHEASTERN TEXAS

ARONOW, SAUL

Windthrows in the Big Thicket National Preserve region of southeastern Texas occur in two kinds of terrain conditions: (1) in well-drained Paleudults on older Pleistocene surfaces where shallow plinthitic and ironstone layers often resist downward extension of taproots and encourage lateral root development and (2) in poorly drained Paleudalfs and Fluviqvents on younger, respectively, Pleistocene and Holocene surfaces where wet ground conditions also restricts taproot growth.

To investigate several aspects of the second kind of terrain condition a monitoring program to extend over several years is under way for a 65 ha tract in the Turkey Creek Unit of the Preserve. All existing (and future) windthrows and cradle knolls are being plotted on a large-scale plane table map. Among the items noted are the tree size and type (if preserved), the volume of disturbed soil, the morphology of the cradle knoll, and the soil series. Quantitative studies on the rate of soil disturbance, and the rate of leveling and filling of cradle knolls are lacking for southern forests. Casual observations in local forests suggest that cradle knolls disappear more rapidly than in northern forests where they persist from tens to hundreds of years. This program may establish this apparent regional contrast and reasons for it.

The study will also include (1) the assessment of the effects of windthrows in creating opening in the forest canopy and the promoting of the germination and growth of light-tolerant forms and (2) periodic photographs from permanent bench marks to record possible deterioration by visitor traffic.

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IV. INFORMATION SCIENCES

## THE NATIONAL PARK SERVICE AND INFORMATION: A NEEDED PARTNERSHIP

DOUGLAS, Charles H.

The amount of information being generated is increasing in a geometrical progression. Data related to managing and long-range planning for natural resources is no exception to the dilemma posed by the enormous amount of available information from all sources. Coping with the environment is an involved enterprise, primarily because the environmental sciences deal with many areas, and thus generate multidisciplinary information.

This paper begins with a brief historical description of the attempts to cope with the information problem by the federal government, commercial firms and universities. The paper then reviews the requirements of a proposed National Park Service Ecological and Environmental Management Information System resulting from an assessment of needs expressed by NPS personnel, policy, and documents. A proposed system design is offered based on an integrated configuration of discrete subsystems. Specific operational considerations are identified and recommendations offered regarding basic systems orientation, operational locations, and computer-related considerations.

Finally, arguments will be presented for showing the system to be a tangible and useful tool whose benefits will exceed the costs and time of implementation.

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BORDEN, F. YATES

The mandate of the National Park Service of use and preservation may appear to be incongruous, but in a management science framework the two concepts are entirely compatible. Preservation of resources implies constraints on the level of use, and use by the public implies optimization by management within the constraints. Visitor carrying capacity in dimensions of number of users over time is the measure for the optimum solution of this management science problem and should be the objective of park management policy. Visitor carrying capacity is the maximum number of users over sustained time that can be accommodated by a park resource without diminishing the resource in its preservation context. When user demand is so much less than the carrying capacity that there is no question that the constraints for preservation are not being challenged, park management is very simple. The strategy could best be defined as laissez-faire. There is not even any justifiable short-term reason to define the constraints or the carrying capacity. These halcyon times are past for most parks. Demand and use are near or exceed the carrying capacities of park systems; constraints are being violated; and expeditious short-term solutions have led to increasing restrictions on use and users. Even if carrying capacities and constraints were known, and in many park systems they aren't, only by careful judicious management can the actual use come close to the carrying capacity and remain within the constraints. Where demand is close to or exceeds the carrying capacity, effective scheduling is required. If use is to remain within the constraints and an effective scheduling procedure is not employed, the use level must be severely restricted below the carrying capacity. In such a case, management itself becomes the most limiting constraint. In order to be able to have an effective scheduling system, the resources of a park system must be comprehensively inventoried. For a back-country hiking-camping system, the inventory must contain at least the trail, sign, and campsite information. To run efficiently, the scheduling system must be automated and have access to the back-country information base.

In this context, a scheduling system was developed for back-country use in the Great Smoky Mountains National Park. Simulation runs were made with 1973 permit data and the results evaluated for management success for the scheme at that time and for carrying capacity estimation. These will be discussed as well as other serendipitous results from having the back-country information base for the Park.

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A RESOURCE BASIC INVENTORY TO  
SUPPORT LAND USE PLANNING FOR  
DELAWARE WATER GAP NATIONAL  
RECREATION AREA

STOTTLEMYER, J. ROBERT

The Park Service has recently developed and applied an automated resource inventory procedure to Delaware Water Gap National Recreation Area providing for the collection, synthesis, and evaluation of information on the biological, physical, social, economic and cultural environment of this park and its vicinity. This inventory is being used to evaluate alternatives in land classification, development location, to formulate management objectives, and initiate an information system for the park.

Environmental components such as soils, hydrology, topography, geology, vegetation and wildlife distributions are mapped, digitized as polygraphs and converted to a grid coordinate system. Resource suitability (capability) indices are developed for these environmental components based upon management and development options available. Correlations among environmental components and their relative importance in suitability determinations is evaluated. Software was developed to test the importance of adjacent cell suitabilities in evaluating primary cell suitability. Several impact models are also examined. The product of this process is a land classification map for land within and coterminous the park.

Based upon the limitations of each land class, a procedure is developed for projecting maintenance costs when developments are located on various land suitability classes. An approach for preplanning estimation of visitor use capacity for suitable park lands is discussed.

Socio-economic data for the region and visitor use data are analyzed to assess and quantify the impact of park development alternatives on resources within and adjacent the park.

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YOSEMITE NATIONAL PARK PLANNING -- COMPUTERIZED DATA RETRIEVAL AND ANALYSIS

MORGAN, M. A. AND SCHALLIOL, G.

The Yosemite Planning Team, National Park Service is utilizing a computerized data retrieval and analysis system -- The Interactive Graphic Resource Information System (TIGRIS).

The Computer Research Corporation of Arvada, Colorado developed the computer graphic software package which consists of several hundred Fortran IV programs. Access to the software package is over commercial telephone lines from a remote cathode-ray tube (CRT) terminal located in Denver, Colorado to the Boeing Computer Services Mainstream-TSO service located near Washington, D.C.

Source maps included natural resources such as vegetation and soils, and existing conditions such as buildings and utility lines. Source map scales range from 1:125,000 (parkwide) to 1:6,000 (developed areas). Data are converted by digitizing point locations along line segments or polygons.

Analytical capabilities include the following:

- (1) Input or modification of digitized features via the CRT or a digitizing tablet connected to the remote terminal.
- (2) Unlimited scale transformation.
- (3) Virtually unlimited selection from the data base by logical and mathematical criteria defined by the user.
- (4) Visual enlargement of all or portions of maps on the CRT.
- (5) Calculation of area and perimeter of any selected polygon.
- (6) Overlay of up to 16 maps at one time with creation of a new file representing logical combinations of the polygons on the selected maps.
- (7) Mathematical and statistical operations of feature attributes.
- (8) Generation of contour lines from random data points.
- (9) Impact analysis via the CRT window or a digitizing tablet.

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DETERMINATION OF VISITOR USE LEVELS FOR YOSEMITE VALLEY, YOSEMITE NATIONAL PARK

SCHILLER, R.J.; REYNOLDS, J.J.; FAKE, T.E.; JANES, E.A.; and van WAGTENDONK, J.W.

The Yosemite Planning Team has developed a methodology for determining visitor use levels for Yosemite Valley. An essential contribution to its development was made by consultants experienced in sociological and environmental carrying capacity, park management, and aesthetics. Scenic-biotic conditions, environmental suitability, visitor preferences, and appropriateness of activities are the fundamental criteria.

A scenic analysis of historic scenic viewpoints and existing scenic views resulted in a mapping of the scenic quality of the entire Valley. A biotic analysis evaluated the relative changes in environmental conditions that have resulted from modern man's influence. Environmental suitability included physical hazards such as potential rockslides, soil characteristics, and vegetation types for specified activities. Appropriate activities were defined from analysis of legislation, objectives, a visitor survey, public workshops, and an alternative selection workbook. Appropriate activities are potentially located by application of suitability analysis and maintenance of the integrity of the scenic-biotic condition.

A design phase is utilized to eliminate unnecessarily duplicated activities, achieve functionality, avoid conflicts, and minimize impacts. Impact assessment and monitoring provide feedback to the design phase. Where monitoring reveals unexpected but excessive aesthetic, biological or social impacts, adjustments to the plan must be made.

Visitor use levels will be the number of people who can participate in appropriate activities in a particular area within acceptable levels of impact. Use levels should be adaptable on a seasonal basis, consistent with both scenic and environmental quality of the Valley and provide a high quality visitor experience.

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## A CONCEPTUAL BACKCOUNTRY CARRYING CAPACITY MODEL

VAN WAGTENDONK, J.W.

In the face of recent increases in backcountry use, Park managers have been forced to set interim use limits for heavily used areas. Inherent in any use limit is the concept of carrying capacity. This paper develops a conceptual model of carrying capacities for backcountry areas.

Carrying capacity is generally defined as the level and character of use an area can sustain without unacceptable changes in the wilderness resource or experience. A conceptual model must not only include ecological, physical, and psychological factors, but must also provide for management input. A comprehensive approach must take into consideration the complex relationships between these factors and optimize the effects of their interactions.

The results of research studies relating use to impact form the basis for the model. These relationships are represented by mathematical equations in order to dynamically integrate the model. The model is then simulated by computer and optimum solutions derived through experimentation and linear programming techniques.

National Park Service  
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## USE OF A WILDERNESS SIMULATOR FOR MANAGEMENT DECISIONS

VAN WAGTENDONK, J.W.

Once carrying capacities have been established for a backcountry area, a means for distributing use in accordance with the desired capacities must be developed. The Wilderness Area Simulation Model provides such a means.

The simulator was originally developed to estimate use patterns under alternative management strategies and assess the impacts of each strategy. Complete information is needed about a wilderness area and its use before the simulator can be run. Specifically, descriptions are needed for the trail network, the characteristics of the users, and the way the users interact with the trails.

Output from the simulator includes encounter and use levels for each trail and campsite over time. The number of encounters a party has is used as a measure of solitude, an important component of psychological carrying capacity. Use levels are related to both psychological and ecological impacts.

Various management strategies called scenarios were run on the simulator to compare the ramifications of the alternative actions. A modified trailhead quota system was found to epitomize management control and user freedom.

National Park Service  
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ANALYSIS OF RHYOLITE CANYON WATERSHED, CHIRICAHUA NATIONAL MONUMENT,  
ARIZONA: A PROTOTYPE STUDY TO IMPROVE THE EFFICIENCY OF NATURAL  
RESOURCE DECISION-MAKING.

MCCARTHY, M. M.\*, FRONDORF, A. F.\*, ALBERT, L.S.\*\*

A functional analysis of the operative resource processes in a major watershed of the Chiricahua National Monument, Arizona has been conducted involving computer graphic techniques and the formation of a data base which shall serve as the foundation of computer-assisted predictive models. The complex physical nature of Chiricahua National Monument, in conjunction with its biological national and international significance constitute a unique area of study, both for the ecologist and the natural resource planner.

A systematic unaligned sample of the study area resulted in a collection of data from a number of one hectare sample sites. Data were collected both from previously existing sources and during on-site investigations. Over twenty-five different types of natural resource data were collected. Each of the data types was further subdivided into as many as eighteen categories. Hierarchical cluster analyses were performed on the collected data and the resulting dendrograms were used to indicate relationships between resource parameters.

From these results, the principle, easily-measured resource parameters were selected for in-put into a computerized geo-information system for the study area. Remote-sensing imagery was relied upon heavily for this data in-put. Base maps of the principle natural resource parameters and weighted composite computer maps of the study area have been produced. A three-axis model for the assessment of critical/significant environments, developed in conjunction with this study, has been applied to the study area and resulted in the computer display of the most/least critical communities of the watershed.

The study results will serve, as the basis of computer-assisted predictive models for management/planning decisions within the monument.

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## MULTISPECTRAL SCANNER DATA: USEFUL FOR PLANNING AND MANAGING THE NATIONAL PARK SYSTEM?

FLEET, HARVEY; MUTH, KENNETH; and FRIES, NANCY

The ready availability of multispectral scanner data from Landsat sensors for virtually all areas of the National Park System suggests that the National Park Service examine the usefulness of these data for planning and management.

A test project in the Congaree Swamp, South Carolina, utilizing reflected radiant energy in wavelengths 0.5 to 0.6, 0.6 to 0.7, 0.7 to 0.8, 0.8 to 1.1  $\mu\text{m}$ , respectively, collected from an altitude of 10,000 feet, generated a map on which water, several categories of vegetation, and fields and clear-cut areas could be distinguished. The 25-foot size of the resolution cells produced excellent detail, but the satisfactory separation of spectral signatures among the many complexly related hardwood communities was not possible.

Although the multispectral technique appears at this time to have high potential for the rapid production and routine updating of maps, high accuracy and objectivity, and low project-by-project cost, several formidable problems must be resolved before the technology can have widespread utility for National Park Service planning and management. Establishment of effective ground-truthing procedures and the separation of spectral signatures, particularly in the areas with mixed plant communities, high topographic relief, varying slope aspects, or extensive exposures of bare soil, rock, ice, or snow (features that are common in most units of the National Park System) are some of the difficulties that must be resolved.

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## USE OF REMOTE SENSING IN THE PARK PLANNING PROCESS

ROOT, R.R.

Park Service scientists, planners, and managers who are utilizing remote sensing data and interpretation techniques are having varied degrees of success as well as some frustration in using this relatively new technology. This paper discusses the source of, and possible solutions to some common problems encountered by users of remotely sensed data.

A comprehensive data base is an essential foundation for the process of planning in existing or proposed national parks. Resource data are absolutely necessary not only for effective planning and use of parklands, but also for adequately assessing environmental impacts of any man-caused physical or managerial changes.

Remote sensing is playing an increasingly important role in collecting and interpreting information on the physical and biological characteristics of the earth's surface. Widespread use of remote sensing technology by both government agencies and private industry has greatly assisted the timely and accurate compilation of data based on reflective characteristics of the earth's surface. However, an occasional misuse or misinterpretation of remotely sensed data has caused confusion among some data users who are not fully aware of the limitations, as well as the full potential, of different types of remote sensors. This paper is intended to reduce this confusion, with particular reference to imagery from the LANDSAT satellites, which is currently in use by many Park Service scientists and planners.

Resource data may be collected at varying scales, or analogously from different altitudes, from close to the earth's surface (low level or very large scale) to a satellite platform hundreds of miles out in space (high level or small scale). Each level, or scale of resource data can provide answers to certain questions about the resource. Logically, the larger the scale the more detail may be extracted from the data. Difficulties arise when the level of data and the level, or scope, of the questions asked do not match. Examples of different levels of remote sensing data and appropriate questions for each of these levels are discussed.

Alaska Task Force personnel representing many different disciplines met at the University of Alaska in February, 1976, to receive instruction in manually interpreting LANDSAT data for the proposed new Alaska parks. Some individuals were highly successful in producing complete, or nearly complete, vegetation maps in a one week period. Other individuals had difficulties in interpreting the LANDSAT data. Reasons for success or failure to produce a map are discussed and related to the concept of asking appropriate questions of a given level of data.

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## COMPUTER- AIDED PARKLAND RESEARCH OPTIMIZATION

GILES, R. H., JR., TIPTON, A. R., SHARIK, T. L., BUHYOFF, G. J. AND ARGOW, K. A.

A generalized parkland research system is described including dominant research needs. The magnitude and frequency of park management problems are increasing while funds, manpower and technological advances are stable or decreasing. Powerful assistance is needed that can be provided by computers and wildland management science.

This paper outlines with examples, the practical aspects of (1) simulation of populations, habitat, and social systems; (2) analyses of systems to enable allocations to be made to the most influential factors; (3) dynamic land classification; (4) computer assisted environmental assessment and impact analyses; (5) feedback and control systems; and (6) policy development that is responsive to regional and world scenarios.

The means are presented for moving the computer beyond data processor to decision aid for research functional in park management and administration.

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AN EVALUATION OF EARTH RESOURCES TECHNOLOGY SATELLITE (ERTS-1)  
IMAGERY FOR DELINEATING SNOW EXTENT: CRATER LAKE NATIONAL PARK,  
OREGON

Rose, Paul W. and James F. Lahey\*

In the Pacific Northwest snow is an important natural resource. The inability to accurately measure or monitor this resource throughout remote areas is a hindrance to water management. ERTS-1 imagery provides the capability for extracting a significant amount of scientific information and data regarding snow conditions in accessible and inaccessible regions of the Pacific Northwest. The area examined to evaluate the utility of the ERTS system was in Crater Lake National Park, Oregon. The actual boundaries of the study area were determined by available high flight aerial photographs of the park. An analysis was made for the snow conditions in Crater Lake National Park and factors affecting snow pack depletion were considered. High flight aerial photographs and ERTS-1 multispectral images were utilized throughout this research. The procedure followed a systematic approach establishing "ground truth" with the aerial photographs. The results from these examinations were then directly applied to the ERTS-1 images. It was determined that ERTS-1 imagery: 1) can be accurately utilized at a much larger scale (1:130,000) than was previously believed by other major researchers; 2) bands 4, 5 and 6 can be used to define maximum snow extent; 3) bands 6 and 7 delimit open areas which are snow covered; 4) rock outcroppings devoid of snow can be determined utilizing band 6; and 5) melting snow is indicated on band 7. These results have potential in the field of snow hydrology for the application of ERTS-1 images to snow pack monitoring, determining areas of concern in "the source area concept," and estimating snowmelt and stream runoff.

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## PREDICTING IMPACTS OF PROPOSED FACILITIES ON PARKS

GILES, R. H., JR., JONES, A. B., TIPTON, A. R. AND SHARIK, T. L.

A computer-based methodology for locating linear facilities within and adjacent to National Parks is described. Alternative sets of weighted objectives can be input to the system to achieve a specific optimum site for facilities such as roads, trails, and utility lines.

A coordinate data base is employed. Actual maps and electronic maps (LANDSAT) can be used. Other maps can be made from created variables, computed factors, and synthetic indices such as visual impact of a power line or insolation within a cell.

The bases for location are

- (1) opportunity cost
- (2) minimum impact or cost
- (3) maximum index to weighted objective achievement

given constraints and the ecological realities of the entire park, park objectives, and likely off-site consequences.

Sample solutions are provided for an area of the Shenandoah National Park.

The methodology can be used in activities associated with proposed crossing of park lands by utilities such as power, gas, or coal slurry corridors.

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## SIMULATING RIVER RECREATION USE: A TOOL FOR MANAGEMENT

LIME, DAVID W.\* AND McCOOL, STEPHEN F.\*\*

The Wilderness Area Travel Simulator developed by Resources for the Future in cooperation with the U. S. Forest Service has been modified to predict patterns of river recreation use that will occur under a variety of use management policies. The Simulator allows the manager to experiment with proposed use management policies in a faster, more efficient manner than an on-the-ground trial-and-error approach. It was field-tested in a 1975 study of rivers in Dinosaur National Monument.

Accelerating use of free-flowing rivers for recreational floating has led managers to initiate interim visitor use limits. Ideally, managers should know beforehand how use patterns and levels of solitude would be affected when use limits are implemented. The Simulator permits such an analysis, and it provides two general types of output: (1) information on amounts and patterns of use; and (2) information on the number of encounters groups have with each other.

Three types of use information are required to operate the Simulator: (1) current use patterns such as number of groups launching by entry point, travel method, and group size for each day of the study period, (2) time, in minutes, to travel various river segments, and (3) route of travel (lunch stop, campsites, etc.). Much of this information is probably available if a visitor use permit is required. Other information can be collected through special study.

In a study of the Green and Yampa Rivers, the Simulator was first used to duplicate existing use patterns for the week of June 23-29. This "Base Case" was compared to actual patterns of use and encounters reported by users to test the Simulator's validity. Agreement was very close. A variety of proposed use management scenarios were run in which daily entry rates were increased and equalized over days of the week. In other scenarios, some river campgrounds were eliminated and new ones created. Such experiments produced significant changes in patterns of use as well as encounters.

The Simulator offers considerable potential in understanding and contending with the problems of increased use in a variety of dispersed recreation settings. It is now operational and available for use by managers in considering a range of approaches to regulate visitor use. The Simulator achieves its greatest utility when the results of sociological and ecological research can be incorporated into the analysis and interpreted.

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THE USE OF SIMULATION MODELS IN PROJECTING POTENTIAL VISITATION TO  
NEW NATIONAL PARK AREAS IN ALASKA

WRIGHT, R. GERALD

Having accurate estimates of the numbers of visitors to National Parks is critical to planning and use of these areas. This paper will summarize a method using simulation modelling whereby estimates might be achieved.

Accurate estimation of the potential number of visitors to National Parks is critical with respect to operating budgets, manpower needs, and future development requirements. In recent years, large variations in visitation to parks have rendered past estimates unreliable, cast doubt on existing methods of visitor forecast, and placed a great burden on park planners who are developing facilities for unknown numbers of visitors. This burden is particularly great on planners working on the vast areas proposed for new parks in Alaska where past use has been negligible, and where the magnitude of future visitation may have important political consequences. This paper will show how computer simulation models can be used to estimate the numbers and regional character of future visitors and to provide insight on the important sources of variation in yearly visitation. A multi-state compartmental flow model is presented, along with the underlying assumptions and rationale behind them. The output of the model is validated against data from Mt. McKinley National Park.

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THE USE OF SPACIAL SIMULATION MODELS IN EVALUATING LAND-USE AND  
RESOURCE MANAGEMENT STRATEGIES IN THE PROPOSED ALASKAN PARKS.

WRIGHT, R. GERALD

This paper reports on past National Park Service planning efforts using overlay analysis and the effect of employing spacial simulation analysis to resolve problems inherent in the former technique.

Planning methodologies for the National Park Service, both at a conceptual and a site specific level have, grown increasingly sophisticated in recent years due in large measure to the requirements of the National Environmental Policy Act. Planning techniques have been oriented primarily to the use of map overlays. The information content on these is often automatically digitized and computer stored to be used in different combinations to provide suitability analyses for different demands. This paper will in part reflect on the values and problems with this type of analysis using recent planning efforts at Great Smoky Mountains and Yosemite National Parks as examples. A major value of this type of approach is that it has spacial resolution; a major problem is that it is non-dynamic in terms of time and component interaction; properties which are possessed by simulation models. This paper will also illustrate how simulation techniques can be applied to the overlay analysis to provide improved methods for looking at the impacts of different land-use and resource management tactics. The model used is being developed as a planning tool for the proposed Wrangell-St. Elias National Park in Alaska.

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THE APPLICATION OF A GEO-INFORMATION SYSTEM TO RESOURCE INVENTORY,  
RESEARCH, AND MANAGEMENT FUNCTIONS IN BANDELIER NATIONAL MONUMENT

TURNER, A. K.\*; RICE, A.\*; HUNTER, J. D.\*\*; VOGEL, R. W.\*

This project used an interactive composite mapping system, called GMAPS, which was implemented at Los Alamos Scientific Laboratory for energy development planning. A suite of maps describing the Bandelier National Monument environment was converted to computer readable format with a 1.1 acre (200 ft. x 250 ft.) ground resolution. The GMAPS programs developed three distinct products: (1) special topic maps and statistics, (2) characteristics of existing or proposed trails, and (3) maps showing optimum sites for facilities.

These products represent an important extension of the traditional planning approach, the drawing of maps on transparent materials, the overlaying of these transparencies, and the redrafting of the composites. The computer-aided GMAPS procedures are much cheaper and faster, and have greater discrimination because they are quantitative. They allow management to investigate a wide range of planning alternatives. The users are responsible for defining the tasks and alternatives.

A variety of display products are available, including computer printer greytone maps, computer-generated color 35 mm slides, and black and white images on CRT terminals. The GMAPS programs are self prompting, and can be operated by nontechnical personnel from portable terminals at field offices via telephone lines.

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## THE APPLICATION OF A GEOGRAPHIC INFORMATION SYSTEM TO THE NATIONAL PARKS

BRIDGES, K. W. AND LIGGETT, W. H.

Maps have always been an important tool in the management of National Parks. As the need for more comprehensive management increases, so does the need for an integrated set of maps. Ideally, these maps will be of high cartographic quality so that they fully convey the information that they contain to planners and decision-makers. A number of geographic information systems have been developed over the past several years which attempt to link the computational and drafting capabilities of the computer. Since the promise of these systems attempts to fill the mapping needs of the Parks, their use as an effective and practical management tool needs to be thoroughly evaluated.

Some of the desirable qualities of these systems include that the system be dispersed into the locations in which it is needed, that it be efficient to operate, that it have sufficient flexibility to adapt to new applications, and that it have a relatively low capital cost. The design of such a system is now available and its use has been tested on a mapping project for Hawaii Volcanoes National Park.

The availability of a geographic database will allow more than the reproduction of the original maps. An appropriate information system will also encourage the analysis of the maps, both individually and in various combinations. It is easy to anticipate that this will provide important new ways to evaluate existing information. However, we know very little about the problems of analyzing such data since we have only recently had sufficient high quality data in a computer readable form to undertake any tests of these methodologies. Close cooperation between the Park managers and the system designers will have to be maintained through this developmental period so that the forms of the analysis match the real management needs.

The time has come to move these geographic information systems out of the developmental laboratories and into extensive field testing.

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V. METEOROLOGY

## AN AIR QUALITY SURVEY OF THE COLORADO RIVER IN THE GRAND CANYON

SCHAEFER, V. J.

For seventeen days, an air quality survey was conducted along 226 miles of the Colorado River in the Grand Canyon. This study was carried out during a routine research expedition of the Museum of Northern Arizona, which has been conducting an ecological survey of the Grand Canyon for the National Park Service. Measurements were made at 13 campsites along the river. Three 36-hour sequences were obtained at Cardenas Creek, National Canyon and Whitemore Rapids.

The air quality concentrations measured included ten particle size categories, ranging from 0.005 to 50  $\mu\text{M}$  diameter, and the three trace gases - ozone, sulfur dioxide and nitrogen dioxide. Relationships were found between a build-up in concentration of Aitken nuclei with an increase in concentration of ozone.

The effect of a cooking fire on the number of particles in the air was also determined. Unusually large temperature inversions were found, which relate to the extremely cold river water and the residual heat acquired by the rocks and sand above the scour channel.

The air quality of the bottom of the canyon is excellent and compares favorably with other parts of the remote areas of the United States which are affected only slightly by man's activities, and is somewhat better than is found in the vicinity of Lake Powell and the Kaiparowits Plateau.

The data obtained in the Canyon constitute a useful bench mark for air quality and should be repeated at yearly and seasonal periods if at all possible.

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## THE YELLOWSTONE FIELD RESEARCH EXPEDITIONS

HENDERSON, T. J.\* AND SCHAEFER, V. J.\*\*

For twelve successive winters, starting in 1959, extensive atmospheric studies were carried out in Yellowstone Park under the sponsorship of the Atmospheric Sciences Research Center of the State University of New York in cooperation with the National Park Service.

The Yellowstone Field Research Expeditions provided four weeks of intensive research studies for scientists and students interested in cloud physics and chemistry, in addition to many other related ecological studies.

More than 200 different scientists (with 84 returning for two or more continuing studies), 31 grad students, 6 undergraduates and 19 high school students participated. Evening seminars were presented every night, and several hundred separate research projects were carried out. Ten of the twelve years were spent in the basin of the Firehole River centered in the Old Faithful area, while the last two years were spent at Norris Geyser Basin. Two-thirds of the participants were from academic institutions, while the remainder were equally representative of federal and state organizations, public organizations and private industry.

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## CLIMATOLOGICAL STUDIES IN YELLOWSTONE AND GRAND TETON NATIONAL PARKS

DIRKS, R. A.

A climatological data inventory was begun for these Parks in 1973. Meteorological data from a wide range of sources were compiled and integrated. From these data, climatic zones were delineated for the Parks and critical data needs were defined. Beginning in 1974, a special network of meteorological stations was installed and operated to broaden the climatic data base, particularly for winds.

The climatology of a region is a critical component in the effective management of the natural environment. Some of the applications of climatological data to environmental management will be briefly discussed. Wilderness Act restrictions are a serious handicap to the use of this management tool. The pristine environment of large national parks provides an opportunity for collecting basic background data on many atmospheric parameters. Maintenance of the quality of the natural environment of our national parks, while providing the best recreational opportunities, requires that parks administrators and scientific researchers work hand-in-hand to optimize environmental management procedures.

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## ATMOSPHERIC MEASUREMENTS AT GRAND CANYON

LAYTON, R. G., MALM, W. C., O'DELL, K. D. AND WILLIS, W. R.

Measurements of air quality have been made on the rim and inside the Grand Canyon of the Colorado since 1972. The types of measurements include:

1. Aitken nuclei concentrations
2. Aerosol particulate concentrations with trace element and sulfate concentration analysis using High Volume samplers
3. Particle size distribution
4. Optical extinction measurements
5. Wind speed and direction
6. Temperatures

Measurements 1 and 2 were made at two locations, South Rim Visitor Center and Phantom Ranch (Colorado River). Measurements 3 and 4 were primarily at South Rim. Measurements 5 and 6 were made at the South Rim, two locations on the Tonto Plateau (inner canyon), and at Phantom Ranch. All air quality measurements indicate a very clean air in the Grand Canyon with seasonal fluctuations. For example, aerosol mass loadings vary from 5 to 40  $\mu\text{g}/\text{m}^3$  while typical Aitken nuclei concentrations range from 400 to 3000 per  $\text{cm}^3$ . The seasonal variations in these measurements will be correlated with meteorological conditions in and around the Grand Canyon.

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## $^{222}\text{Rn}$ AND AIR EXCHANGE IN THE CARLSBAD CAVERNS

WILKENING, M. H.

A series of measurements of  $^{222}\text{Rn}$  concentrations in the Carlsbad Caverns was begun in February of 1973 for the purpose of exploring the natural circulation within the cave and for estimating exposure levels to people visiting or working in the cave. When outdoor air is warmer than cave air ( $14^{\circ}\text{C}$ ) as occurs in the summer months, the cave atmosphere is stable and  $^{222}\text{Rn}$  concentrations average 48 pCi/l. In the winter cold, and hence, heavier air from outside having a  $^{222}\text{Rn}$  concentration of only about 0.2 pCi/l mixes with cave air reducing radon levels to about 15 pCi/l. A model obtained by setting the input of  $^{222}\text{Rn}$  atoms from the rocks and soils of the cave's interior equal to the sum of terms for radioactive decay and dilution of the cave atmosphere by outdoor air makes it possible to predict the  $^{222}\text{Rn}$  concentrations to be expected within the Caverns at different seasons of the year. The annual mean level is about 35 pCi/l based upon the model and measurements from four sampling periods during 1973-1975. These results are consistent with those expected in underground cavities in rocks and soils containing only normal trace quantities of  $^{238}\text{U}$  and  $^{226}\text{Ra}$ . However, if one assumes equilibrium between  $^{222}\text{Rn}$  and its short-lived daughters, personnel working regularly underground approach the exposure limit established for the uranium industry.

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## ALPHA RADIATION MONITORING AT CARLSBAD CAVERNS

AHLSTRAND, G. M. AND FRY, P. L.

Alpha radiation associated with natural disintegration series may present an internal radiation hazard to the lungs of long-term underground employees. Radon and its radioactive decay products occur naturally in many caves, but only recently has their presence been documented. In this paper, results from a year long continuing study of alpha radiation levels in Carlsbad Caverns are presented.

Transient equilibrium can be established between radon-222 and its short lived daughters (polonium-218, lead-214, bismuth-214, and polonium-214) in about three hours. At any given radon emanation rate, radon daughter levels within the cave depend primarily on exchange rates between cave and outside air. The natural entrance to Carlsbad Caverns is at the top of the cave. During the winter months dense (cold) outside air flows down the entrance passage into the cave and displaces less dense (warmer) cavern air. Increased air exchange rates effectively lower the radon daughter concentrations within the cave. The rate of exchange slows during the summer months as minimum outside air temperatures seldom are below or even equal the cave air temperature.

Although temperature differentials are apparently the primary factor affecting air exchange rates and radon daughter levels in Carlsbad Caverns, changes in atmospheric pressure appear to coincide with fluctuations in the radon concentration.

Other studies are in progress to better understand and characterize the radon problem. Although the study of radon and its daughters continues, there is no evidence to date that the alpha radiation levels present in Carlsbad Caverns present a health hazard to either visitors or employees.

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VI. SOCIOLOGY

PLANNING URBAN PARK: EMPHASIS ON GATEWAY

KORNBLUM, WM.

Planning Gateway National Recreation Area, 26,000 acre National Park facility in the New York and Jew Jersey Metropolitan Area is a case study in urban political ecology. Since 1972 when the park was created by Congress new interest groups have continually emerged to add their demands to the range of issues which had been raised before the park opened.

The present research paper describes the processes whereby interest groups emerge in various urban settings. The paper further details the type of negotiations and outcomes which characterize the activities of social groups that make the allocation of Gateway resources their concern.

Conclusions drawn from study of the Gateway planning experience are applied to the theory and practice of public involvement in the National Park Service in general. Recommendations are made which are intended to advance the progress of public advocacy in National Park Service planning in urban regions.

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PANEL DISCUSSION: MAJOR ISSUES IN THE AREAS OF OUTDOOR RECREATION  
AND RESOURCE MANAGEMENT

CHAIRMAN: CHEEK, NEIL

PANELISTS: \*\*BERTRAND, ALVIN, \*\*\*BURCH, WILLIAM AND \*\*\*\*BULTENA,  
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PANEL DISCUSSION - NO ABSTRACTS SUBMITTED

A REPORT ON THE PACIFIC NORTHWEST REGION'S SOCIOLOGY STUDY PROGRAM

CHAIRMAN: \*FIELD, DONALD R.

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NO ABSTRACT SUBMITTED

VISITOR USE STUDIES IN NATIONAL PARKS--WITH SPECIAL EMPHASIS ON  
YOSEMITE

LEE, ROBERT G.

There has been a recent increase in the number of visitor use studies in national parks. Researchers represent a wide range of universities and National Park Service regions. However, issues of theory, measurement and research implementation have yet to be evaluated comprehensively. This paper will discuss these issues in the context of sociological investigation of visitors to Yosemite National Park.

Generally, visitor use studies have lacked unambiguous theories of leisure and recreation, refined measurement techniques, and an understanding how results may be made useful to agency decision-makers. Most theories of leisure and recreation are still in the developmental stage. Too often they are informed by common-sense thinking and managerial concerns. The usual substitute for a theoretical framework has been the linkage of standard demographic variables to rates of participation in selected activities. Future visitor surveys can be strengthened by using theories of culture and social group behavior to interpret user behavior in national parks.

Visitor use studies have relied almost exclusively on interviews and questionnaires as measurement techniques. Yet many of the results from these methods are of questionable validity: convergent and discriminant validation has not been demonstrated. In studies of crowding among the backcountry visitors to Yosemite results from questionnaires did not converge with results from behavioral observations.

Research results are more readily adopted by decision-makers when data are presented in the context of management problem-solving. Researchers in the Park Service play an essential role in communicating new information. The primary function of applied sociology at Yosemite has been to expand the repertoire of choices for managing visitor behavior and meeting visitor needs.

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## SOCIAL SCIENCE AND POLICY RELEVANT RESEARCH

HAAS, J. EUGENE

There is a potential, mutually beneficial relationship between mission-oriented governmental agencies and social science researchers in universities and private firms. Too often each has an inadequate understanding of the needs and constraints within which the other must operate. Examination of the various facets of that potential relationship suggests that the public interest is best served when both the agencies and researchers stress candor, work only with appropriately trained and competent personnel, involve relevant peers and budget realistically.

Examples are drawn from research relationships existing over the past decade between various Federal agencies and social science research groups.

Problems of organizational autonomy, survival, centralization of decision making, cooptation, adaptability and trust are considered and suggestions for change are offered.

The limits of social science research are outlined in a comparative framework and the implications of those limitations for policy relevant research and government agency action are considered.

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STRATEGIES FOR THE ASSESSMENT OF SOCIAL-PSYCHOLOGICAL CARRYING CAPACITIES OF WHITEWATER RIVERS--A COMPARATIVE ANALYSIS

SCHREYER, RICHARD\* AND ROGGENBUCK, JOSEPH W.\*\*

Concern over crowding in the recreational use of whitewater rivers has resulted in increasing attention to the determination of human carrying capacities for such resources. However, assessment of social-psychological perceptions of carrying capacity is seen to be more than a simple summation of user responses to seeing other users or to key managerial options. As whitewater river users may have diverse and conflicting perceptions just which sector of the public it will seek to serve by its decisions.

A survey of whitewater river recreationists on the Green and Yampa Rivers in Dinosaur National Monument during the summer of 1975 was carried out to assess different dimensions of the user perception aspect of carrying capacity. Two theoretical perspectives which can potentially guide managerial decisions are compared with the traditional strategy of managing for the average of mass demand in order to illustrate the need for specification of clientele: (1) Experience expectations - identifying and managing for subgroups on the basis of motives for taking a river trip, and (2) Primary management clientele - identifying and managing for the subgroups of users whose definitions of the resource and its values are closest to the institutional definitions of that reserve (e.g., a wilderness Whitewater River). A comparative analysis of perceptions of crowding using mass demand, the experience expectation, and the primary management clientele theoretical approaches demonstrates that a range of carrying capacities is possible, depending upon the group studied. Implications for management are discussed.

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A PROFILE OF PRIVATE RIVER USE IN THE GRAND CANYON AND CANYONLANDS  
NATIONAL PARKS

DEKKER, E. A.

Managers currently face the dilemma of allocating a limited number of river use permits between the commercial and private sectors. Present allocations are criticized as restricting private users proportionately more than commercial passengers. This paper presents a profile of private users in order to assess the nature of their demand for whitewater ventures.

Participants in private trips through the Grand Canyon and Cataract Canyon (Canyonlands National Park) were surveyed to determine their demographic characteristics and experience in running whitewater rivers. The data show that private users are a predominantly young group of whitewater enthusiasts from the far western states, who run a variety of rivers on a fairly regular basis.

Contrary to the general hypothesis, little evidence was found of a pattern of succession from commercial to private river use. Rather than experiencing their first whitewater trip with a commercial outfitter, individuals are apparently introduced to river running by acquaintances who have prior experience. Some displacement is apparently occurring as a result of the increasing use of whitewater rivers.

The appeal of private -- as opposed to commercial -- trips lies in the comparatively low cost, the adaptability of scheduling, and the opportunity to participate in all aspects of trip planning and implementation. It is concluded that the private sector accommodates a distinct group of users whose desired experience is not now provided by the commercial sector.

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# ELEMENTS OF MOTIVATION AND SATISFACTION IN THE FLOAT TRIP EXPERIENCE IN BIG BEND NATIONAL PARK

Graefe, A.R. and Ditton, R.B.

People float wild and scenic rivers for many reasons. This paper reports an analysis of float trip objectives, or motives for participating in float trips. The paper compares the types of experiences that are sought by floaters with the types of experiences that are obtained to yield a measure of user satisfaction with the activity.

Mail questionnaires were sent to a sample of party leaders for 1975 float trips on the Rio Grande in Big Bend National Park. The framework for measurement of motivation and satisfaction was a list of alleged trip objectives which had been previously suggested in the literature to be important elements of the experience. For each objective, respondents indicated on Likert type scales how important the objective was to them as a reason for floating and how well their trip performed at fulfilling the objective.

Outputs of the analyses include: (a) determination of which objectives are more important to floaters in Big Bend (rank order importance), (b) determination of which objectives are better fulfilled by float trips in Big Bend (rank order performance), (c) analysis of between groups differences for objective importance and performance, with groups differentiated by managerially distinct categories of users and by similar motive patterns, (d) determination of which conditions contribute to satisfaction and dissatisfaction, and their degree of contribution, by comparing standardized importance and performance ratings, and (e) analysis of between groups differences in satisfaction patterns.

Findings are discussed in light of related river-oriented research, and implications for management of the riparian resource are considered as well as generalizability of the research design as a means to gain user input for recreational resource allocation decisions.

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A POPULATION OF LOCAL FISHERMEN AND THEIR PERCEPTIONS OF CHANGE IN  
A RIVER ENVIRONMENT

CHILMAN, KENNETH C. AND MARVIN BROWN

The objectives of the study were: 1) to measure and describe the population of fishermen on the Lower Current River (Ozark National Scenic Riverways in Missouri) in terms of characteristics and past and present fishing habits, and 2) to determine what perceptions these fishermen have of other river users (especially the rapidly increasing numbers of canoeists) and how these perceptions affect fishing habits. This is one of a series of studies designed to aid in a carrying capacity determination for the Riverways.

ASSESSING VISITOR SPATIAL DEMAND THROUGH FOREST-USER DENSITY  
PREFERENCES: TOWARD A SOCIAL CARRYING CAPACITY MODEL

BECKER, ROBERT H.

Social carrying capacity of a selected forest area was explored through a hypothesis that there exists discernible patterns of forest recreation. These patterns were held to be a function of user density over the forest space. It was hypothesized that users consciously or unconsciously sought out areas within the spatial proximity for their recreational experiences. These user groups, within each respective zone, would exhibit greater homogeneity than would users of the general forest space. This zonal exclusivity would be an effective means of classifying user groups and predicting user preferences. This hypothesis was manifest in three operational study objectives: (1) to determine user perception of the recreational system of the study area; (2) to evaluate the compatibility of state forest management objectives to user experience perception; (3) to examine forest users recreation perception in relation to the actual user behavior.

The recreational system was delimited as components related to: (1) area recreation behavior; (2) forest facilities and alterations; and (3) forest management practices. Twelve attitudinal statements related to these components were examined.

A 3 x 2 factorial multiple analysis of variance (MANOVA) was utilized to examine differences between user groups. The three level factor was the use density areas of the forest in which users were confronted. The two level factor was the type of visit the user engaged in, i.e. day visitor or overnight camper. Density levels were calculated from a division of a random sample (drawn over the forest space) user frequency count via the Harvard University SYMAP program. Responses on twelve attitudinal statements were collected on a Likert five point scale with polar extremes of the scale representing a user's primitive bias to outdoor comfort bias. Six hundred sixty respondents were sampled, 220 users in each zone, 110 users in each of the six cells. The MANOVA was repeated, re-classifying users on an optimal density zone preference criteria, rather than on the observed density zone in which respondents were seen.

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## PREVALENCE OF SOCIAL INTERACTION IN A NATIONAL PARK

HAAS, G. E.

The intent of this study was to examine the amount and level of verbal communication experienced among campers in a National Park family-campground setting. A matrix was developed to measure this social interaction. Along the horizontal axis were categories of interaction arranged in a theoretical hierarchy. The underlying rationale for this hierarchy was the probable increasing duration of interaction and decreasing impersonalization. On the vertical axis were categories of people interacted with, forming conceptual concentric rings at varying distances from the respondent's campsite.

Data revealed that social interaction is a very prevalent phenomenon. Approximately 81% of the respondents interacted with members of neighboring campsites, while 79% interacted with other campers in the campground. Approximately 75% interacted with park naturalists, while 60% interacted with other visitors to the park.

A direct relationship existed between the level of interaction and the distance from a respondent's campsite. The greater the distance, the higher the percentage of "no" and "low" interaction, while the lower the percentage of "medium" and "high" interaction. The most personal interaction, and of longest duration, occurred primarily with members of neighboring campsites.

Perhaps most consequential was that interaction involved not only passing conversation but learning people's origin, learning their names, and meeting for a second time. These data imply that within the package of satisfactions experienced in a National Park setting, interacting with "strangers" may be a highly desirable attribute. Such an attribute could have numerous managerial implications relative to program planning and park design.

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MULTIDIMENSIONAL BELIEFS OF YOUTH TOWARD NATIONAL PARKS

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Attitudes of a middle class, white sample of 600 youths were measured toward national parks. An attempt was made to determine the extent of value orientations which such a sample of youth would have toward national parks. Two distinct factors emerged from the analysis identifying the need for outdoor recreation and a wilderness experience. The factors reflected playfulness and solitariness on the part of the youth. Influences of parents and peers, past park experiences and general leisure attitudes were hypothesized as being possible predictors of such park attitudes. The model was most effective in predicting attitudes toward solitariness for the older male and female adolescent. The playfulness factor was not significantly effected by the independent variables, thus calling for a reexamination of the model.

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PAY-AS-YOU-PLAY: AN ANALYSIS OF ATTITUDES TOWARD A FEE-FOR-USE  
APPROACH TO OUTDOOR RECREATION

GRIMES, M. D., PINHEY, T. K. AND CAMPOS, D. E.

This study reports the results of a survey of the attitudes and evaluations of a representative sample of Louisiana residents concerning the issue for fee-for-use as a tool for increasing outdoor recreational opportunities. Results centered on four popular outdoor recreational activities--two "consumptive" activities, hunting and fishing, and two "appreciative" activities, camping and public beaches. Analysis of our results indicated that (1) fee-for-use was recommended as a means for increasing outdoor recreational opportunities by about one-third (32.2 percent) of our total sample, (2) that the modal amount our respondents were willing to pay for one unit's use depended upon the activity in question, and (3) that variables such as income, occupation, education, age, place of residence, ethnicity, sex and participation in the particular activity affected the modal response. Discussion follows on the implications of fee-for-use as a means for increasing outdoor recreational opportunities.

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## DIFFERENTIATING USER PUBLICS BY MULTIPLE DISCRIMINANT ANALYSIS (MDA)

HORNBACK, K., GALIPEAU, A., TRENT J.

Visitor use studies such as those conducted at Sequoia and Yosemite NPs were of little use to managers and planners as long as they were only available in aggregated form. Planner's and manager's problems are usually specific and require general information about the visiting public to be segmented accordingly. Presenting all available descriptors of user publics, however, is confusing and often prompts the naive conclusion that there are no differences among user groups. Special Public Use Descriptions (SPUDs) were prepared to overcome the problems. SPUDs present only those descriptive attributes which differentiate specified user groups from park visitors in general by multiple discriminant analysis. A SPUD may be prepared for any planning or management problem which involves some definable subset of the visiting public. Plans for campground changes, for example, would call for a Campground SPUD. SPUDs may be prepared for user groups by activity, season, area of use, etc.

MDA isolates attributes which serve to distinguish among groups. MDA can also be used to classify cases. Classification is the process of identifying the probable group membership of a case when only case values on certain discriminating variables are known. Thus, if managers or planners want to know the distribution of visitors among various types given specified changes in visitation patterns (times, sources, modes, or other group discriminating variable), the classification function would be used.

SPUDs enable the manager and planner to know the size and composition of the segment of the public which will be relatively more affected by actions on sites, programs, facilities, or any other aspect of park planning which can be defined as a criterion (dependent) variable for MDA. SPUDs using MDA are an example of applied utility of sociological data gathered in visitor use studies conducted by Denver Service Center planning teams.

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## MILESTONES IN FOREST SERVICE RECREATION RESEARCH

SHAFER, ELWOOD L.

Major findings of the Forest Service Recreation Research Program are presented for the 15-year period, 1960-1975. Published knowledge and methodology of the program is evaluated in terms of: applicability of results to various locations and audiences, and how closely the amounts of information produced match program-priority needs. Sixty important research-information milestones, which are being or can be used by managers and recreationists, are described.

The research milestones deal with knowledge and methodology to...

1. Measure, maintain, protect and augment the supply of forest-related recreation environments.
2. Understand demand for and the associated underlying benefits and values of forest-oriented recreation.
3. Improve capabilities of management to integrate changes in demand and supply, and to coordinate supply-demand relationships with other forestry practices.

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## INTERPERSONAL BEHAVIOR IN CITIZEN INVOLVEMENT WORKSHOPS

BRODIE, D. Q., and TAYLOR, Susan F.

The Great Smoky Mountains National Park Master Planning Team requested the development of a citizen involvement process which would include citizens from thirteen counties in North Carolina and Tennessee. The goal of the citizen participation was to establish the citizens' priorities for the region for the year 1990.

A group process was developed based upon the sampling principles of survey design and the group process techniques of A. L. Delbecq and A. H. Van Den Ven.

This paper reports on the substantive outcomes of the group workshops and the group dynamics of the workshops. Using the observation techniques developed by Robert F. Bales (Personality and Interpersonal Behavior), two questions concerning the group process are examined.

- (1) Was there a group in which everyone was active?
- (2) Were there individuals who unduly influenced the groups?

Using data collected by group observers, each group was plotted on a spatial model of group structures. The plotting of the groups provides evidence that in each group all individuals participated and were involved in the task of establishing priorities. Also, the plotting indicates that no group was unduly influenced by any single participant.

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PANEL DISCUSSION: SUMMARY, REVIEW AND FUTURE DIRECTIONS OF SOCIO-  
LOGICAL RESEARCH IN MISSION ORIENTED LAND MANAGEMENT AGENCIES

CHAIRMAN: \*KEY, WILLIAM H.

PANELISTS: \*\*FIELD, DONALD R., \*\*\*DAVEY, STUART, \*\*\*\*SHAFER,  
ELWOOD AND \*\*\*\*\*ADAMS, DARRELL

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\*\*\*\*\*Bureau of Land Management

PANEL DISCUSSION - NO ABSTRACTS SUBMITTED

VII. TERRESTRIAL BIOLOGY

- A. BOTANY
- B. RIPARIAN BIOLOGY
- C. RESOURCES MANAGEMENT
- D. ZOOLOGY

## BIOSPHERE RESERVES, MAB AND THE NATIONAL PARKS

Franklin, J. F.

The Biosphere Reserve concept was developed as a major element of Project 8, Conservation of Natural Areas and of the Genetic Material They Contain, in the UNESCO-sponsored Programme on Men and the Biosphere. They have three basic purposes or objectives: conservation or preservation, research and monitoring, and education. Conceptually, the core of the Biosphere Reserve program is a system which includes natural areas representative of the major biotic divisions of the world. It is the existence of or potential for major ecological research and monitoring programs which distinguishes the Biosphere Reserves from other conservation or preservation systems or programs in the United States. Twelve of the 29 U. S. areas established are administered by the National Park Service. None of the 29 completely satisfy all criteria - a large, strictly-preserved tract for conservation and a substantial history of research and monitoring including the potential for major experimental treatments. Because of this, the United States developed the concept of multiple reserves whereby experimentally-oriented tracts are matched with large preserves similar in biological and environmental features. The selected Biosphere Reserves are seen as major centers for preservation of biotic and genetic diversity and for ecological and environmental research in the biotic province they represent; they are biologically outstanding representatives of these provinces. Anticipated scientific uses include: (1) long-term baseline studies of environmental and biological (community, flora, fauna) features; (2) research to assist in management; (3) experimental studies on ecological effects of human activities; (4) environmental monitoring; and (5) study sites for the various MAB research projects. The impact that designation is liable to have on research, monitoring, and management activities on National Park areas will be discussed.

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## FIRE AND GIANT SEQUOIA REPRODUCTION

Harvey, H. Thomas

Under the direction of R. J. Hartesveldt a ten year study was begun in 1964 in Sequoia and Kings Canyon National Parks on fire and giant sequoia reproduction. Four study plots were established in the Redwood Mountain Grove of giant sequoias, in which various burning techniques were employed.

The four major aspects of the study were successional trends, factors affecting sequoia seed and seedling production and survival, vertebrate interaction and invertebrate interaction with giant sequoia seeds and young seedlings. The successional trends were monitored via permanent plots in manipulated and control sections. Giant sequoia seed and seedling production was studied through sampling and total population investigations. Animal activities were observed directly as they affected giant sequoia reproduction. For the first time, in-tree observations were made in the crowns of mature giant sequoias.

Successional trends following the fire manipulations included rapid influx of annuals, shrubs and tree species, then within a few years the annuals had dropped to zero and shrubs and tree seedlings were reduced. Giant sequoia seeds are produced in great numbers in serotinous cones so that thousands of seedlings may develop per hectare under favorable conditions. The hotter the fire, apparently the better the substrate condition for the seedlings. Summer soil desiccation was determined to be a major mortality factor. Vertebrates had an extremely low preference for sequoia seeds and the douglas squirrel appears to feed on the cone scales, but not the seeds. Only about 20 species of insects were known to be associated with the giant sequoia prior to this study; now over 100 are known to depend on this tree. A small beetle feeds in the green cones causing them to dry and release their seeds.

Intermittent surface fires which would result in a mosaic of conditions seem to best insure perpetuation of the giant sequoia ecosystem.

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THE SAGUARO GIANT CACTUS: AN ECOLOGICAL PERSPECTIVE

Steenbergh, Warren F.

The National Park Service has long been concerned with the nature and cause of dramatic fluctuations in populations of the saguaro cactus (Cereus giganteus Engelm., Carnegiea gigantea [Engelm.] Britt. and Rose) in certain portions of Saguaro National Monument. This report summarizes the results of investigations designed to provide definitive knowledge of the nature and operation of environmental factors that control the population structure and limits of the saguaros' distribution in this northern portion of the species' range.

The relationship of environmental factors to the germination, establishment, survival and growth of young saguaros, and causes of saguaro mortality, are discussed. The status of saguaro populations at Saguaro National Monument are discussed in relation to historical factors.

Recurring catastrophic freezes are the single most important natural environmental factor affecting saguaro populations at Saguaro National Monument and elsewhere in the colder portions of the species' distribution. Gross changes in the density and age structure of these populations observed during this century are the direct result of natural selection by recurring catastrophic freezes.

The saguaro is well adapted to maintain itself in environments where occasional freezes occur. In such environments freeze-caused catastrophic die-off is followed by regeneration of the population during periods of climatic remission. The apparent decline of some northern saguaro populations--including those at Saguaro National Monument--may be but one phase of the normal fluctuation of populations whose stability is ultimately measureable, not on a scale of years, but rather, on the evolutionary time scale of generations.

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THE FLORA NORTH AMERICA PROJECT AND ITS PROSPECTIVE  
CONTRIBUTIONS TO BIOLOGICAL RESEARCH IN THE  
NATIONAL PARKS

by LARRY E. MORSE

Flora North America (FNA) would contribute in several ways to the quality of scientific research in the U.S. (and Canadian) national parks. The major goals of the project are production of a floristic treatise on the vascular plants of North America north of Mexico, and development of a computer-based data bank concerning these data and associated information.

We anticipate further work on Flora North America would concentrate first on production of a unified taxonomic checklist for vascular plants in the FNA territory, followed by preparation of synoptical species treatments done insofar as possible by experts in the various taxonomic groups. These treatments would then be critically reviewed taxonomically, geographically, and ecologically, thus potentially involving virtually all plant systematists in the United States and Canada in some aspect or another of the project.

As presently planned, the FNA project would contribute in many ways to biological research in the national parks, in such diverse areas as administration and management; staff and non-staff research; utilization of published literature; and Park Service programs of publication and interpretation.

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## THE NATURAL LANDMARKS PROGRAM

Waggoner, Gary S.

The National Park Service administers two programs to preserve nationally significant natural areas: the National Park System and the Natural Landmarks Program. The Natural Landmarks Program is a recognition program to encourage the voluntary preservation of significant natural areas on non-Park Service administered lands. Natural region studies and onsite evaluation studies are conducted by scientists under contract to the Service. Sites determined to be nationally significant are entered on the National Registry of Natural Landmarks by the Secretary of the Interior.

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NATURAL AREA CLASSIFICATION SYSTEM: A STANDARDIZATION SCHEME

<sup>1</sup>RADFORD, A. E., AND <sup>2</sup>PITTILLO, J. D.

Any natural area classification system should include biotic assemblages (vegetation with accompanying fauna), climatic regime(s), soil system(s), geologic formation(s), and land form(s) by physiographic province hierarchically arranged with each entry at each level circumscribed and encoded. The System proposed represents an effort to produce a basic standardization scheme for more efficient and effective inventory and storage and retrieval of information on natural areas, vegetation, floras, and rare, endangered, and threatened species.

The natural themes for any province are Vegetation (with animal dependents), Climate, Soils, Geology, and Topography. These are interacting but independent systems that compose the Ecosystem. The proposed system would rank systems (as community system, community subsystem, community class, community cover type, community subtype) against columns specifying vegetation, fauna, climate, soil, geology, etc.

The vegetation classification is based primarily on plant form and aquatic or topographic features. The community Systems are non-aquatic (I-VII) or wetland (VIII-XIV) and may include successional communities. The community subsystems are based on six rock types (A-F). Community classes (1-112) indicate the community dominant (e.g. Spruce-fir forest) while the basic community type would utilize vegetative strata (e.g. Fraser fir--Low herb). The community subtype would be a local variant (as Fraser fir--common wood sorrel or Fraser fir--mountain woodfern).

The advantages of the system are that it is designed to include all ecosystem components and can allow existing classification systems, especially vegetation systems, to be incorporated into one data banking system.

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## ALTERNATION AND COEXISTENCE OF TREE SPECIES

FOX, J. F.

In virgin forests, individual trees tend to be succeeded after death by trees of another species. The phenomenon was recognized by a French forester and named alternation of species as early as 1905. In small patches where, by accident, trees of only one species are present in the overstory, another species may be unusually well represented in the underlying sapling layer. Even where there is a mixture of species in the overstory, there is a significant association between the species of tree in the canopy and species composition in the sapling layer directly beneath it. 'Alternation' contributes to community stability by determining the ratio of species at equilibrium and by driving the community toward an equilibrium in species composition following disturbance.

In a virgin Fraser fir (F), red spruce (S), yellow birch (B) forest (Great Smoky Mts. N.P.), the numbers of saplings (1"-13" DBH) within 3 paces of a canopy tree (16"+ DBH) bole were: for canopy F (n=25), 50 F, 50 S, 18 B; under canopy S (n=25), 126 F, 17 S, 8 B; under canopy B (n=27), 77 F, 21 S, 1 B. Fir saplings are associated with spruce overstory and vice-versa. In a virgin beech (B)-sugar maple (M) forest in SW Michigan, there were 24 M and 81 B saplings beneath canopy areas exclusively dominated by M, and 69 M, 17 B under B-dominated patches. Where the species are mixed in the canopy the association weakens (80 M, 90 B under M; 47 M, 27 B under B); similar results obtain in a virgin beech-hemlock forest (Allegheny N.F.).

From the sapling size distributions I infer that these differences arise largely before saplings are 2" in DBH, thus involving differential seed predation and/or seedling mortality. Seedling mortality is being studied in the Smokies and in a virgin spruce-fir forest in Wyoming (Medicine Bow N.F.).

Coexisting climax species also tend to occur as pairs, of which the longer-lived grows faster in the sun but more slowly in the shade than the other. This yields a frequency-dependent mechanism for coexistence by alternation; its quantitative importance is under study.

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THE ORIGINAL SURVEY NOTES OF THE PICTURED ROCKS AND APOSTLE ISLANDS  
NATIONAL LAKESHORES AND THEIR USE IN RECONSTRUCTING ORIGINAL FORESTS.

FREDERICK, D. J., RAKESTRAW, L., EDER, C. R., VAN DYKE, R. A., GRIEWE,  
B. J., AND M. A. ANDERSON.

Using the 1841-1857 General Land Office survey notes of the Pictured Rocks and Apostle Islands National Lakeshores (both on the south shore of Lake Superior), methods are described for transcribing and interpreting data and drafting original vegetation type maps. Final type line placement utilizes current soil survey maps and U.S. Geological Survey maps. A computer mapping technique using the same source information is described and compared with manual methods.

The original surveys and surveyors of both Lakeshore areas are described and compared. The detail and accuracy attained by these surveyors is also contrasted.

Using these maps along with accompanying information from the original notes on topography, soils, site quality, disturbances and human presence, a general comparison is made with present conditions. Significant vegetational changes have occurred on both areas resulting from man's incursions. The practical uses of such vegetation base maps are also presented.

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ORIGINAL FOREST VEGETATION AND THE LAND-USE HISTORY OF THE APOSTLE  
ISLANDS NATIONAL LAKESHORE.

RAKESTRAW, L., FREDERICK, D. J., EDER, C. R., VAN DYKE, R. A., AND  
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The forests of the Apostle Islands at the time of the original survey (about 1857) were virtually undisturbed and consisted of mixed northern hardwoods, hemlock, white pine and cedar. Since that time nearly all the original forests have been exploited. The present forests of the National Lakeshore area bear little resemblance to the original forest cover due to a complex land-use history. We report here the land-use patterns which have contributed to these changes.

Most of the individual islands within the National Lakeshore have reasonably uniform topography and geology but have had different histories of fire, logging, quarrying, browsing and agriculture. The dominant disturbance factor has been logging for sawlogs, pulp, hemlock bark, wood for charcoal and fuel wood for Lake Superior steamers. Several islands were railroad logged with the logs being either floated or barged to nearby mills in Ashland and Washburn.

The present island type maps used for comparison with the original forests were assembled using aerial photographs, data from the State of Wisconsin, U.S. Forest Service and Northland College.

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## ECOLOGY OF SAND VEGETATION OF THE APOSTLE ISLANDS

Jefferson, Carol A.

During 1975-1976, 26 sites on sand in the Apostle Islands and adjacent Bayfield Peninsula in Wisconsin were sampled to determine the floristic composition, plant communities and developmental history. Included were sand spits, tombolos, beaches, dunes and a moraine. About 300 species of vascular plants, bryophytes, and lichens were identified and 12 communities defined: Beach Strand; Beach Grass; Jack Pine-White Pine/Blueberry/Lichen; Red Pine; Black Spruce; Red Oak/Bracken; Balsam Fir-White Spruce; Deflation Plain; Rush Swamp; Grass-Sedge Slough; Alder Thicket and Bog. Most of the sites are on parallel ridges and runnels whose pattern of geologic development corresponds to vegetational development. Logging, fires, grazing, browsing and cultivation have affected the composition of the present vegetation.

The original vegetation probably was a pine barren, but after the logging of the 1890's- 1940's, most of the white and red pines were cut and the area burned. Today the resultant jack pine-dominated vegetation is present on several sites, but now is succeeded by an open oak woods on the inner islands and peninsula. The oaks are absent from the outer islands, where the older forest includes many boreal species. The wetlands succeed from sloughs and swales to forested swamps and bogs.

Species presence and cover were sampled with regularly placed plots in selected stands. A point-centered quarter method was used along transects. Development of the soil profile was noted.

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PLANT COMMUNITIES OF THE PARALLEL RIDGES AND TROUGHS OF PRESQUE ISLE POINT, STOCKTON ISLAND, LAKE SUPERIOR, IN RELATION TO GEOMORPHIC PROCESSES AND WATER LEVEL HISTORY.

Coffin, Barbara Ann

The origin of the parallel ridges and troughs that form a neck of land joining Presque Isle Point to the main body of Stockton Island, in the Apostle Islands region, is found to be related to water level history, currents, and wind. These have been active here since glacial times. The parallel ridges, sand dunes and/or old beach shorelines, are found in varying states: active aggrading dunes, stabilized but sparsely vegetated ones, and those covered with forest. The troughs are narrow strips of wet sphagnum bog with some open ponds still present.

The topography of the neck creates distinct community boundaries related to depth of water table. They were recorded and analyzed according to the Braun-Blanquet Releve Method. Broad old dune ridges forested by northern hardwoods mixed with conifers enclose a 16 ha. triangular sphagnum bog of Ericaceous shrubs and scattered Tamarack (*Larix laricina*) and Black Spruce (*Picea mariana*). Extensive coring in this bog has revealed an ancient lake floor. Peat and lake sediments are as much as eight meters deep in the central basin. Northeast of the forested dune ridges is a series of five parallel sand ridges separated by 5-10 m. strips of sphagnum bog. Adjacent to these ridges stretches a long narrow lagoon enclosed by a dune-beach barrier which borders Lake Superior and forms the northeast side of the neck.

Radiocarbon dating and palynological study of the cored sediments are under study, to aid in clarifying the physiographic history.

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THE SEQUIADENDRON GIGANTEUM EXHIBIT AT THE WORLD'S COLUMBIAN  
EXPOSITION IN CHICAGO, 1893

McGRAW, DONALD J.

The discipline of botany and that of history converge in research on the General Noble Tree, a specimen of Sequoiadendron giganteum displayed at the Chicago "World's Fair" of 1893. Believed to be a definitive history, this discussion includes a variety of new information not previously published.

In a few semi-popular historical accounts of the logging of the Giant Sequoia in California, the story of the Noble has been recounted. These short vignettes are often illustrated with several of the Charles C. Curtis photographs of the cutting operation. Little information beyond the antiquarian appeal of the story is given.

Considerably more information regarding the cutting operation, such as previously unpublished photographs, names and biographies of those involved, and the subsequent history of the display section is now available. It is believed this exhibit played a role in public education in exposing the existence of the Giant Sequoia to the doubting midwestern and eastern American populace.

In what has been called a "California Hoax", a section of Big Tree exhibited in the Quaker Centennial in Philadelphia in 1876, was discarded as a prank thrust upon the American public by California wags. The Noble exhibit did much to dispell this attitude.

The history of the display section is traced from its cutting in 1892, through its exhibit in Chicago in 1893, to its long-term stay as an exhibit on the Mall in Washington, D.C. Its final disposition has remained mysterious, although a fascinating, though unsubstantiated, hypothesis of its current resting place is offered.

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## POLLEN STUDIES OF ANCIENT LAKE SEDIMENTS IN ZION NATIONAL PARK, UTAH

HEVLY, R.H.

Lava and land-slide dammed drainages in Southwestern Utah impounded lacustrine sediments of Pleistocene and Post-Pleistocene age whose pollen content permits reconstruction of past vegetation and climate.

Recent studies have documented the occurrence of Pleistocene and Post-Pleistocene lakes in Zion National Park. These lakes were apparently formed by the damming of ancient drainages by lava flows and/or land slides. The following localities have been studied: Sentinel Slide Lake, Taylor Creek Slide Lake and Bog, Coalpits Wash Lake, and Trail Canyon Slide Lake. These localities may be characterized as occurring between 4,000 and 6,000 feet elevation in Pinon-Juniper Woodland with bordering Pine-Oak-Fir Forest in adjoining coves and Chaparral on adjoining exposed south facing slopes. Near streams which border the sample localities abundant riparian deciduous trees occur in association with a variety of aquatic herbs.

While a variety of macro- and micro-fossils are present, only the pollen of seed plants was recovered in sufficient quantity from the relatively more fine textured and organic strata to determine the relative abundance of major types. Pollen, spore and algal relict data definitely indicate that these finer textured sediments represent lacustrine depositional environments. Paleoclimatic conditions seem to have changed significantly since the end of the Pleistocene when conditions were sufficiently cooler and moister that spruce, fir, douglas fir and ponderosa pine were dominant plants where now pinon pine, juniper, and oak predominate. At least once during the Post-Pleistocene environmental conditions have undergone a significant fluctuation suggestive of the classical tripartite subdivision of the Post-Pleistocene widely documented in western North America.

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PALYNOLOGY OF THE GALLATIN MOUNTAIN "FOSSIL FORESTS" OF YELLOWSTONE  
NATIONAL PARK, MONTANA: PRELIMINARY REPORT

DEBORD, PHILLIP L.

The "Fossil Forests" of Yellowstone National Park are unique not only because they cover a large area (over 40 square miles), but because we find the petrified vertical stumps of one forest on top of another. We find this sequence repeated numerous times in the Gallatin Mountains. This study is concerned with the reconstruction of the paleoclimatology, paleoecology, and depositional history of these "Fossil Forests" based on the palynoflora and megaflora.

Ninety palynology samples have been taken from a measured section (335' vertical distance) approximately one mile northwest of the junction of the west and east forks of Specimen Creek. Taxonomic study of over 130 forms is in progress. The palynoflora recovered from the thin organic zones associated with vertical stumps indicates a flora with great ecological and taxonomic diversity. Pteridophytes, bisaccate gymnosperms and Taxodiaceae are abundant. Of the angiosperms, *Carya*, *Acer*, *Planera*, *Ilex*, *Salix*, ?*Populus*, and *Momipites*, are well represented. *Alnus* and *Ulmus-Zelkova* are particularly abundant.

Because of such diversity reconstruction of the history of the "Fossil Forests" will only be accomplished when investigation in other areas of Yellowstone and in other disciplines have been completed.

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HOLOCENE VEGETATIONAL HISTORY OF THE LAKE MINCHUMINA AREA,  
MT. MCKINLEY QUADRANGLE, ALASKA

Ager, Thomas

A pollen record spanning about 8700 years has been obtained from a sediment core from Lake Minchumina, interior Alaska (63°55'N, 152°13'W). One core segment (437-457cm) of the 556 cm core has yielded a radiocarbon date of 6805 ± 230 yrs.B.P. (GX-4230). Extrapolation permits tentative dating of vegetation events interpreted from pollen data from the core. The pollen diagram from Minchumina resembles the core I diagram from Birch Lake in the middle Tanana Valley to the east. The Minchumina pollen diagram can be subdivided into three informal subzones. Subzone "a" is characterized by very low percentages of alder pollen, low percentages of spruce (1-8%), and high percentages of birch pollen (80-90%). Subzone "a" spans core interval 490-556 cm (ca. 8700-7500 years B.P.). Subzone "b" is typified by high birch pollen percentages (60-80%), rising alder percentages (4-27%), and rather consistently low spruce percentages (4-8%). Subzone "b" spans core interval 375-490 cm (ca. 5700-7500 years B.P.). Subzone "c" is characterized by higher spruce pollen percentages (17-60%), moderate birch percentages (30-55%), and alder percentages of 12-24%. Subzone "c" spans the upper 375 cm of core (ca. 5700 years B.P. to present). If the single radiocarbon date proves to be correct, the vegetation history implies that spruce and alder arrived at Lake Minchumina considerably later than in the Tanana Valley to the east. The low spruce pollen percentages in the core interval 375-556 cm suggest that spruce was rare or absent in the Minchumina area until perhaps 5700 years B.P. vs. ca. 10,000 years B.P. in the middle Tanana Valley.

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THE ECOLOGY OF SAWGRASS IN THE EVERGLADES OF SOUTHERN  
FLORIDA

HOFSTETTER, RONALD H. AND PARSONS, FRANCES

Sawgrass, Cladium jamaicense Crantz, is the dominant plant in the Everglades of southern Florida. It exists in both expansive pure stands and as a component in several other plant communities. Relatively little is known about the nature of growth, factors affecting growth, and the ecological importance of this species. Currently sawgrass is declining in both vigor and distribution throughout the Everglades.

This paper reviews briefly existing information on sawgrass. New data are presented on the nature of growth of the individual culms, on litter production and decomposition, and on community energy production. The role of hydrologic conditions, fire, hurricanes, competition by native and exotic species, insect feeding, and man is assessed relative to the decline of sawgrass. If existing conditions continue, significant changes in the communities of the Everglades should be anticipated. Some management procedures essential for maintaining the well-being of the Everglades are presented briefly.

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# SEASONAL AND ENVIRONMENTAL DIFFERENCES IN NITROGEN AND PHOSPHORUS CONCENTRATIONS IN SAWGRASS IN SOUTHERN FLORIDA

PARSONS, FRANCES

Sawgrass, Cladium jamaicense Crantz, is the dominant macrophyte in large areas of Everglades National Park, Florida. This paper is a report of studies of the changes in concentration of phosphorus and several nitrogen compounds in sawgrass and the underlying sediments through an annual cycle in several locations in the graminoid wetlands in southern Florida.

The plants and sediment were considered as contiguous compartments of a community column. The compartments assigned were as follows: green leaves, brown leaves, inflorescence, when present, and roots of living sawgrass. Other compartments were: ground water, when present, and three depths of the underlying peat. The compartments were sampled at one site considered to be least disturbed by man's activities at approximately monthly intervals and analysed for Kjeldahl nitrogen and total phosphorus. Soluble components studied were ammonia, nitrate, nitrite, and phosphate. Other sites exhibiting differing degrees of apparent robustness of growth and suffering varying environmental pressures (e. g. frequent fires, extended drydown) were sampled seasonally. The nutrient values and the differences in stature of sawgrass found at these sites are compared with those of the reference site. Correlations are shown between various plant components such as ash and percent moisture as well as the nutrient constituents.

The soluble nitrogen compounds in the plants and sediment comprise a small fraction of total nitrogen. The same is true of soluble phosphate and total phosphorus. Ammonia and nitrate are seasonally negatively related in roots and green leaves. Ammonia and nitrate are likewise seasonally negatively related in the sediment, however, the greatest amount of the reduced form is found during the winter dry season when surface water is lowest and the greatest amount of the oxidized form is present during the summer rainy season when surface water is deepest. The sediment composition within each site is extremely variable with respect to the above nutrients, but seasonal variation is apparent.

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EVIDENCE OF HURRICANE INFLUENCE ON BARRIER ISLAND SLASH PINE  
FORESTS: MORPHOLOGY, WOOD ANATOMY AND GROWTH RELEASE PATTERNS

\*STONEBURNER, DANIEL L. AND \*\*MILLER, GERALD J.

The pervasive existence of pine-dominated forests on barrier islands in the Gulf of Mexico has been an unexplained anomaly in a region where live oaks are considered to be the dominant forest types. The effects of hurricane processes are discussed as a major factor contributing to the anomaly.

Insular slash pine (*Pinus Elliotii* Engelm.) forests, growing in the Mississippi unit of the Gulf Islands National Seashore, were critically examined for evidence of hurricane effects. The widespread instance of hurricane-induced windthrow, overwash and accelerated salt spray has produced differential patterns in the age and size class distributions in these island forests. The forest configuration and growth patterns obtained from living trees are discussed as the result of repeated hurricane incidence.

Data obtained in this study indicate that repeated hurricane processes are prerequisite for the maintenance of the pure slash pine forests, growing on a chain of barrier islands, located along the Mississippi Gulf Coast.

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## VEGETATION OF THE CUMBERLAND ISLAND NATIONAL SEASHORE

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A vegetational analysis of Cumberland Island, Camden County, Georgia, was conducted in 1973 for the National Park Service. The study was intended to provide data for development of management guidelines for the Seashore.

Quantitative measurements of interior vegetation were made at 250 sample points on the island. Qualitative measurements of beach, dune, and interdune vegetation were made along 10 transect lines. Successional relationships of the various communities were projected from sampling data, aerial photographs, and presumed effects of natural and man-influenced changes.

Twenty-three communities were described and mapped for the island within the following categories: dunes, interdune flats, salt marsh, fresh water, upland forests, and miscellaneous. Succession develops toward a mixed hardwood forest dominated by several sclerophyllous evergreen species, most often live oak (Quercus virginiana). On wet-acid sites succession tends toward broad-leaved evergreen, bay type vegetation. We interpret the mature forests of Cumberland as subtropical in nature, since these forests are dominated by broad-leaved evergreens, show floristic affinities with tropical forests, and occur in a moderate oceanic climate. With the exclusion of fire over many decades, pine forests change gradually in composition to predominantly oaks and other hardwoods.

Cumberland Island is not a virgin wilderness. It exists today in a semi-wild state, greatly modified by the land uses and management practices of earlier inhabitants.

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## THE MAJOR PLANT COMMUNITIES OF THE FIRE ISLAND NATIONAL SEASHORE

Stalter, Richard

Fire Island, a barrier island composed primarily of quartz sand, lies from three fourths of a mile to three miles south of Long Island. Three main plant communities can be found within the National Seashore: the sand dune community, favoring areas of light to heavy salt spray, bright sun, and shifting sands; the salt marsh community, whose species tolerate varying amounts of soil salt content and tidal flooding; and the sunken forest, dominated by *Ilex opaca*.

The sand dune community is dominated by *Ammophila breviligulata*. Other dune species include *Artemisia stellariana*, *Cakile edentula*, *Euphorbia polygonifolia*, *Solidago sempervirens*, *Hudsonia tomentosa*, *Rhus radicans*, *Myrica pennsylvanica*, *Arctostaphylos uva-ursi*, and others. The species of the salt marsh community listed in increasing elevation above datum include *Spartina alterniflora*, *Salicornia* spp., *Limonium carolinianum*, *Iva oraria*, and *Baccharis halimifolia*. The sunken forest is dominated by holly (*Ilex opaca*). *Quercus velutina* (one dead specimen was at least 180 years old), *Amelanchier canadensis* (one having a circumference of nearly four feet), *Sassafras albidum*, *Acer rubrum*, and *Nyssa sylvatica* are the most common arborescent species in the forest. Rarely more than 20 feet tall, the sunken forest is truly a unique ecosystem. The location of the island, the shade tolerance of holly, the presence of a high complex dune system, and the presence of salt spray probably account for the dominance of *Ilex*.

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THE FOREST COMMUNITIES OF MAMMOTH CAVE NATIONAL PARK

FALLER, A.\*, JACKSON, M.T.\*\*

The forest communities of Mammoth Cave National Park were sampled by the Bitterlich variable radius method in 38 separate stands. Stand attributes of density, basal area and percent importance were used to prepare an ordination analysis based on similarity between stands. These stands associated, in ordination space, into six forest types. The forest types include: 1) slope and upland oak-hickory stands dominated by white oak (*Quercus alba*), black oak (*Q. velutina*), pignut hickory (*Carya glabra*), and several other hickory species; 2) mesophytic old growth stands in deep hollows; 3) chestnut oak (*Q. prinus*) dominated stands on Pennsylvanian aged sandstone uplands; 4) eastern hemlock (*Tsuga canadensis*) dominated stands with American beech (*Fagus grandifolia*) and magnolia (*Magnolia acuminata*, *M. macrophylla*); 5) floodplain stands dominated by sycamore (*Platanus occidentalis*) and maples (*Acer saccharinum*, *A. negundo*); and 6) successional stands on abandoned farm land where black gum (*Nyssa sylvatica*), dogwood (*Cornus florida*), winged elm (*Ulmus alata*), and tuliptree (*Liriodendron tulipifera*) are dominant. Areas restocked with either Virginia pine (*Pinus virginiana*) or black locust (*Robinia pseudo-acacia*) were not included in the ordination analysis.

The successional plant communities reflect two major trends. The first involves a moisture gradient from hydric to mesic conditions, e.g. on the larger and higher floodplains of the Green River and its tributaries. This gradient is reflected in the change in dominance from sycamore and silver maple to American beech and sugar maple (*A. saccharum*). The second involves a time gradient of recovery on abandoned agricultural land where the early stages are dominated by black gum, dogwood, and winged elm, while older stages are dominated by blackjack oak (*Q. marilandica*).

Average basal area ranged from 8.8 m<sup>2</sup>/hectare in some successional stands to 41.3 m<sup>2</sup>/hectare in floodplain stands with limited disturbance. Old growth stands, which are remnants of the Western Mesophytic Forest, occur in sinks and deep hollows. These had the greatest arboreal species diversity with more than twenty-five species contributing to the canopy. Density ranged from 343 stems/hectare in some old growth stands to 787 stems/hectare in successional stands.

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PRAIRIE RESTORATION AT PEA RIDGE NATIONAL MILITARY PARK, BENTON COUNTY, ARKANSAS.

DALE, EDWARD E., JR., AND GIBBONS, JAMES

Prairie restoration studies have been made in various parts of the United States, but not in Arkansas. In this paper we report studies on prairie restoration in this area.

A one acre (.405 hectare) plot was plowed and disked in April and June, 1975, and soil nutrients adjusted to approximate conditions in nearby areas supporting native prairie. A total of 12 pounds (5.443 kilograms) of seeds, including Andropogon Gerardi, A. scoparius, Bouteloua curtipendula, Sorghastrum nutans and Panicum virgatum, were broadcast on June 13. The area was raked, trampled, and mulched with straw, and test plots established to determine effects of various seedbed treatments on seedling establishment. Prairie forbs were introduced by transplanting.

Germination was noted 10 days after planting, and establishment of a good stand of prairie grasses was obvious by August. Also, 10 species of prairie forbs, including Euphorbia corollata, Solidago canadensis, Shrankia uncinata, Rudbeckia hirta and Cassia fasciculata, became established naturally.

Weed species that became prominent in 1975 include Mollugo verticillata, Diodia teres, Ambrosia artemisiifolia, Bidens aristosa and Digitaria sanguinalis. Weed growth was severely inhibited in areas with good stands of prairie grasses, and adequate weed control was obtained by hand removal and mowing.

Survival of grass and forb transplants into the second year was excellent, but forb survival during 1976 was adversely affected by deer.

Statistical studies showed that the only treatment of seed beds that significantly improved establishment was raking after sowing.

Our studies indicate that prairie restoration in northwest Arkansas is feasible.

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INVESTIGATION OF VEGETATIONAL COMMUNITIES IN JOSHUA TREE NATIONAL MONUMENT

Leary, Patrick, and Niles, Wesley E.

Since Joshua Tree National Monument came into the Park Service some forty years ago, no thorough vegetational analysis has been conducted. This project is a survey of perennial flora of Joshua Tree, an area encompassing 900 square miles. The emphasis has been to define plant communities by applying statistical and ordinating techniques to transect data. A vegetational map of the Monument has been constructed. Data concerning various perennial plant species includes frequency, distribution, percent cover and community affinity. Information from this study will be useful in helping to determine management policy for bighorn sheep, mule deer, public use, etc., and to lay the foundation for future research.

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## VEGETATION OF CANYONLANDS NATIONAL PARK, UTAH IN RELATION TO ENVIRONMENT

LOOPE, W. L. AND WEST, N. E.

The vegetation of Canyonlands National Park, Utah has been described from 157 samples located throughout the Park. Species frequency, density and cover data were recorded along with measurements of soil depth, slope, aspect, elevation and geologic substrate at each site. Measurements of soil texture, pH, and electrical conductivity were taken for a representative subsample. A map of the vegetation of the Park was made by relating the sample points to their corresponding spectral signatures on aerial photographs and drawing boundaries associated with changes in photo signatures.

Vegetation in these arid to semi-arid environments appears to be strongly related to regolith depth, geologic formation and water table relationships. Elevation and slope/aspect control vegetation patterns to a much smaller extent. Vegetational units are distinct and can be readily visualized. The six map units designated (in order of relative importance) were: blackbrush, juniper-pinyon woodlands, semi-desert grasslands, sagebrush-fourwing saltbush, shrublands, salt desert shrublands and riparian tall shrublands. These vegetational units are related to specific combinations of environmental factors. Boundaries between units are sharp vegetationally and environmentally. Moisture availability appears to be the key factor, but effective soil moisture is largely controlled by regolith/bedrock relationships.

Grasslands predominate at all elevations where regolith is over 50 cm in depth and there is no access to plant roots to the water table. Regolith that is uniformly shallower than 50 cm supports vegetation dominated by blackbrush (Coleogyne ramosissima). Sandy areas with immediate access to the water table support thickets of Salix, Tamarix, and other riparian shrubs. Brushlands dominated by Atriplex canescens and Artemisia tridentata occur on deeper sand deposits with access to capillary water only. Where competent bedrock is exposed and joints are developed, Pinus edulis, Juniperus osteosperma and various upland shrubs dominate. Several species of Atriplex dominate the salt desert shrub type where tight shales outcrop.

Historical use by domestic livestock has altered the composition and cover in grasslands in the southern part of the Park the most. Elsewhere, grassland modification is slight because of the relatively more difficult access. Other types have experienced less obvious changes.

Many abandoned roads exist within the Park dating chiefly from extensive mineral exploration in the early 1950's. Secondary succession on these disturbed areas is extremely slow.

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DISTRIBUTION AND ECOLOGICAL RELATIONSHIPS OF TWO MOUNTAIN  
HEATHS (PHYLLODOCE) IN OLYMPIC NATIONAL PARK

OLMSTED, INGRID, C.

Ecology and distribution of Phyllodoce empetriformis and P. glanduliflora in subalpine and alpine habitats of Olympic National Park were studied. Specific attention was given to the water relations of both species.

The mountain heath Phyllodoce empetriformis is a common shrub of the subalpine ecosystem in the Olympic Mountains and occurs rarely in the alpine zone; while P. glanduliflora grows mostly in the alpine zone and only infrequently at timberline. When sympatric, the two species hybridize.

Environmental components of the habitat of both species were measured. Ecological requirements of the habitat, tolerances and phenologies are different for the two species in each vegetation zone. The ericoid leaf habit was examined with regard to water stress. Water stress measurements were made with a pressure bomb. Distribution of the two species was further investigated by doing germination and seedling establishment experiments in the Phytotron.

From considerations of Phyllodoce's reproductive potential and survival capacity, suggestions will be made as to its stability under recreational impact in a heavy use zone of Olympic National Park and similar areas. Successional trends will be mentioned.

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## OBSERVATIONS ON SNOW ALGAE IN CALIFORNIA

THOMAS, WILLIAM H.

Algae that impart a red color to snowfields are rather common in California. Red snow occurs mainly in the Sierra Nevada (including Yosemite and Sequoia-Kings Canyon National Parks) at altitudes of 10,000-12,000 ft (3050-3660 m) and can occur at high altitudes where snow persists in other parts of the state. The distribution in the Sierra was similar in 1969 and 1970, contrasting snowfall years. Colored snow was found from May to October in old, wet snowfields. The predominant color was red and occurred as surface patches in depressions in the snow. The color could extend as deep as 30 cm below the snow surface.

Algae in the snowfields of the Tioga Pass area (Sierra Nevada) were large, red, spherical cells of Chlamydomonas nivalis. No other algae were seen. Their distribution, as measured by cell numbers and chlorophyll a, was patchy. Algal cells and chlorophyll a were mainly distributed at or near the snow surface but extended down to a depth of 10 cm. Light intensity was greatly attenuated by snow, but enough light for photosynthesis was found at 50 cm below the surface. Nutrient content of one snow sample was very low. The populations were very actively photosynthetic and took up as much as 65% of added  $^{14}\text{C}$  in only 3 hr. It was tentatively concluded that  $\text{CO}_2$  limits in situ photosynthesis. Photosynthesis was inhibited by melting snow samples. Rough calculations of the growth rate suggested in situ generation times of only a few days for these algae.

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## FOREST ECOSYSTEMS OF MOUNT RAINIER NATIONAL PARK

MOIR, W. H., HOBSON, F. D., HEMSTROM, M., AND FRANKLIN, J. F.

In 1975 we began studies to classify forests at Mount Rainier National Park (MRNP), characterize their biological and environmental features, and determine causes and rates of succession. This paper reports our current knowledge.

Classification was based on data collected in mostly mature forests from 242 plots distributed over all drainage systems. Forests of the *Tsuga heterophylla* zone were limited to lowest elevations; those of the *Abies amabilis* zone are prevalent to about 1580 m elevation. Above this occurs subalpine parkland or forest-tundra ecotone. We recognized 16 major forest associations to 1580 m.

Moisture and temperature gradients are important environmental complexes governing distribution of forest types. These gradients can be described physically by elevation, soils, landform, and relief in each drainage system. The wettest drainages are Carbon and Mowich Rivers; the driest, Ohanapecosh. Soils range from shallow, mixed colluviums of steep slopes; layered tephras of varying iron-pan development; and deep, wet soils of benches, lower slopes and alluvial or lahar surfaces.

Disturbances (fire, avalanche, landslides, lahars) produced forest ages of under 100 years, 100-250, 450-575, and over 900 years. Forests of these ages need to be arranged into chronosequences for each association. Several seral types are first generation on recently deposited soil materials.

The different forests at MRNP have varying hardiness and durability to visitor usage. Visitor accommodation and opportunity to meet expectations (scenery, wildlife encounters, solitude, interpretations, etc.) depend upon forest type and successional stage.

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## ECOLOGY OF ALPINE TIMBERLINE IN OLYMPIC NATIONAL PARK

FONDA, R. W. AND LEMON, G. V.

Alpine timberline in the Olympics is formed by subalpine fir. The vegetation pattern at timberline is a result of the interactions of topography, wind exposure, snow accumulation and melt, soil moisture, and air and soil temperature. These factors combine to make timberline a site with neither too much nor too little snow.

Basins and leeward concavities, which can accumulate as much as 5 m of snow in winter, mark the limits of timberline along one end of the environmental gradient. Sites that are released from snow after early July support subalpine sedge communities. Tree seedlings cannot tolerate the snow compaction nor the short growing season caused by late snow release.

Snow does not accumulate as deeply on windward sides of ridges so that there is no winter protection. Here high winds, high daytime temperatures, and low soil moisture combine to act against the trees during the growing season. Drought is important in the exclusion of trees from higher ridges and convexities. Conditions on the windward slopes create soil drought in summer, so that all plants show decreased water potentials late in the growing season. Poor overnight recovery on extreme sites will exclude trees from early snow release meadows. In August, meadow species on windward slopes show lower water potentials than adjacent timberline trees. The lower water supply through the summer shortens the growing season for timberline trees, compared to the same species in the continuous forest 300 m lower. Consequently, timberline on windward slopes represents a point where trees show an early cessation of growth and low biomass accumulation.

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## REDWOOD VEGETATION DYNAMICS

VEIRS, Stephen D.

Sequoia sempervirens dominates the redwood forests of coastal northern California. Its ecological status is disputed. A climax species for some, other observers see it as a long-lived fire dependent sub-climax type. Careful elucidation of the natural dynamics of redwood vegetation is essential to long term management of the redwood parks of the region.

An intensive investigation of forest history in selected stands near Redwood National Park has provided new insight into fire frequency and its impact, tree establishment, growth rates, longevity and mortality, primary and secondary succession and other aspects of redwood vegetation and the processes which maintain it.

Sequoia sempervirens, Pseudotsuga menziesii, Tsuga heterophylla, Abies grandis and Lithocarpus densiflorus each display different responses to fire and other environmental factors which result in their persistence in this vegetation type. S. sempervirens is a long-lived fire tolerant climax species which is best developed where fire frequency is low. P. menziesii is a long-lived associate and fire or disturbance dependent seral species. T. heterophylla, A. grandis and L. densiflorus show adaptations which suggest they are components of a climax vegetation type.

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AN INTRODUCTION TO VEGETATION OF THE PROPOSED ANIAKCHAK CALDERA  
NATIONAL MONUMENT AND ITS ENVIRONS ON THE ALASKA PENINSULA  
OF ALASKA

DENNIS, JOHN G.

Aniakchak Caldera National Monument has been proposed for addition to the National Park System to preserve, study, and interpret not only the geological features of the caldera and the area affected by its eruptions, but also the ecological features of the resident and migratory, terrestrial, aquatic, and marine biota that occupies an environment impacted by repeated deposits of volcanic ash. An initial, rapid survey of the plant community portion of this biota has shown the area to contain a mixture of plant communities and environments representing features characteristic of both Aleutian Island and Interior Alaska vegetation types.

Plant communities of the Aniakchak portion of the Alaska Peninsula include latitudinal treeline groves of Populus balsamifera, shrublands of medium to tall Salix spp. or Alnus crispa, dry tundra of Dryas octopetala-dwarf heath-dwarf Salix-forb species, moist Empetrum nigrum tundra, moist heath shrub-dwarf willow-Carex-Sphagnum tundra, Calamagrostis canadensis grass-forb meadow, and Carex-Menyanthes trifoliata-Potentilla palustris marsh. Environmental factors identified to date that influence species composition and distribution of these communities include parent material (rock, ash, or organic) and drainage. Contraction crack polygons in ash fields occur both on the Bristol Bay coastal flat and on the flat terrain of the middle portion of the Peninsula east of Meshik Lake. Seasonal soil frost at the 50 cm depth was encountered in one low, wet area in mid-July. The development of a detailed understanding of the Aniakchak area vegetation, the relationship of that vegetation to meso- and microenvironment, and the long term influence on the vegetation of repeated depositions of volcanic ash will require intensive study.

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PRIMARY VERSUS SECONDARY SUCCESSION AT GLACIER BAY  
NATIONAL MONUMENT, SOUTHEASTERN ALASKA

LAWRENCE, DONALD B.

Vegetation development on till following recession of glaciers in the heart of the Monument has taken about 80 years to reach mature alder thicket stage. At Lituya Bay farther west, where a giant wave swept away the forest but not all the soil, alder forest has developed in only 15 years. Non-leguminous woody plants with symbiotic nitrogen-fixing root nodules have played a major role in clothing the landscape.

Succession following recession from termini mapped by John Muir, 1879-99, has been studied since 1916, first by W. S. Cooper, then by this author. The m<sup>2</sup> plots are now mostly covered with Sitka Alders (Alnus crispa sinuata) 10 meters tall, whose seedlings didn't get established for over 50 years. Results provide a model for understanding primary development of vegetation following continental glaciation because of catastrophic recession, 105 km in 200 years. The more remote the seed sources of plants capable of symbiotic atmospheric nitrogen fixation the slower is vegetation development, the more depauperate the individuals, and the less the biomass produced. Alpine Avens (Dryas drummondii) rose family, and Sitka Alder, birch family, are the most important nitrogen accumulators.

At Lituya Bay, on the Pacific coast of the Monument, surviving tree alders (Alnus oregona) to the windward, beyond the reach of the giant wave of 1958, have provided seed. Fifteen years later, in 1973, resulting trees were already 12 meters tall. Greater species diversity here is probably due to survival of underground stems, roots able to produce adventitious buds, and viable buried seeds.

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## SEED CONTENT OF SUCCESSIONAL AND MATURE EVERGLADES ECOSYSTEM SOILS

EWEL, J. AND CONDE, L.

Succession on recently acquired abandoned farmlands within Everglades National Park is strongly influenced by the kinds and numbers of seeds present in the soil. We determined the viable seed content of soils from five successional stages and two mature, undisturbed communities.

The five successional stages were: freshly disked farmland; 2.5-year-old unburned regrowth (dominated by Ludwigia peruviana); 2.5-year-old regrowth, burned six months prior to sampling (also dominated by L. peruviana); 17-year-old woodland (dominated by Myrica cerifera); and 30-year-old forest (dominated by Schinus terebinthifolius, an exotic tree). The two mature ecosystems were a hardwood hammock forest and a seasonally flooded glade dominated by herbaceous plants. All sites were within 3 km of one another and three were contiguous. The viable seed content was determined by monitoring greenhouse germination from three 0.25 m<sup>2</sup> samples of surface soil from each site.

Eighty-five species have been recorded. Only one of these was found on all seven sites and about half were restricted to single sites. Exotics constituted about 15 percent of the observed species; a fraction similar to that of most weedy floras. About ten percent of the species were woody, only one of which was exotic.

The number of seeds per unit area was relatively constant within sites but varied greatly among sites. Younger successional stages had many more viable seeds than did the mature communities. Viable seed densities ranged from about 130 m<sup>-2</sup> in the hardwood hammock to almost 26,000 m<sup>-2</sup> in the unburned Ludwigia stand. The numbers of both individuals and species of seeds were higher in the successional ecosystems than in the mature communities, but the seed diversity was much higher in the mature ecosystems. This was due to a more equitable distribution of seed among the species found within the mature systems.

Farming in the seasonally flooded glade lands has probably resulted in soil and drainage changes which have produced a new substrate for plant growth. The colonizing flora does not include an unusually high proportion of exotic species, but because these substrates are unique some exotics may become conspicuous, unremovable components of the new ecosystems currently emerging there.

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# MYCORRHIZAE: THEIR ROLE IN SUCCESSION ON ABANDONED EVERGLADES FARMLAND

MEADOR, R.

Mycorrhizae, symbiotic associations between fungi and the roots of most higher plants which aid in plant nutrition, can influence the direction and floristic composition of succession on abandoned farmlands within the Everglades National Park. I examined the mycorrhizal status of plant roots in five successional and two mature ecosystems and found that mycorrhizal infection in the successional ecosystems is different from that of the mature glade ecosystem which previously occupied the site.

The five successional stages were: 1) farmland disked 2 months prior to sampling, 2) 2.5-year-old regrowth (dominated by *Panicum purpurascens*), 3) 2.5-year-old regrowth, burned in June 1975 (dominated by *Ludwigia peruviana*), 4) 17-year-old woodland (dominated by *Myrica cerifera*), and 5) 30-year-old forest (dominated by *Schinus terebinthifolius*). The two mature sites were: 6) a seasonally flooded glade and 7) a hardwood hammock forest. All sites except the hardwood hammock are flooded from June through November. The importance value of higher plant species at each site was determined by biomass harvest in sites 1, 2, 3, and 6 and by basal area measurement in sites 4, 5, and 7. Root samples of each species were cleared, stained, and examined microscopically to determine whether or not they were infected by mycorrhizal fungi.

Mycorrhizal fungi from each site were identified by planting soybeans in soil from each site to permit endomycorrhizal propagules in the soil to infect the soybean roots. The fungi were given sufficient time to fruit and the spores were then extracted from the soil and identified.

Mycorrhizal plants were found in all sites except the seasonally flooded glade. The lowest percentage of mycorrhizal plants in the successional sites was found in the farmland disked 2 months prior to sampling. Mycorrhizal plants were dominants at the other sites. Between 2 and 30 months after abandonment, mycorrhizal plants dominate the community.

No mycorrhizae were discovered in the seasonally flooded glade, indicating that this ecosystem may be non-mycorrhizal: a rarity in natural terrestrial ecosystems. Because mycorrhizal plants have an advantage in nutrient absorption over non-mycorrhizal plants, farming practices which would allow mycorrhizal plants to establish in the glades could change the structure of the glade ecosystem to one dominated by mycorrhizal plants.

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## FACTORS ASSOCIATED WITH FAILURE OF GIANT SEQUOIA

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Interest in public safety and protection of old-growth giant Sequoias motivated an interdisciplinary study of the causes of uprooting and stem failure of large trees. Of 33 recently fallen trees, 16 had carpenter ant (mainly *Camponotus modoc*) galleries in or adjacent to the zone of wood failure. Root or stem decay was found in the failure zone of 30 trees. Both decay and carpenter ant galleries were associated with fire scars. Of 27 trees with fire scars, 26 fell to the scarred side.

High populations of carpenter ants were found both in groves subject to heavy or to light human use. The diet of carpenter ants consisted mainly of honeydew from aphids on understory white firs, not of human refuse. When ants were excluded from aphid colonies, the colonies disappeared as a result of predation.

Nine basidiomycetes, including *Fomes annosus*, *Armillaria mellea*, *Polyporus Schweinitzii*, *Poria albipellucida*, *Poria incrassata*, *Stereum hirsutum*, and *Polyporus versicolor*, were isolated from decayed wood at the zone of tree failure. Microscopic examination of discolored wood associated with carpenter ant galleries showed early to moderate stages of decay. We have not yet determined if ants vector decay fungi or facilitate their spread within the wood.

Our studies indicate that decay was the primary cause of failure in old-growth giant Sequoias.

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VEGETATION OF HIGH-ELEVATION DISTURBED COMMUNITIES IN  
GREAT SMOKY MOUNTAINS NATIONAL PARK

LINDSAY, MARY

Disturbed high elevation communities of Great Smoky Mountains National Park, including grassy balds, shelter clearings, old fields, and burn scars were studied to determine the effects of environment and disturbance on the vegetation.

Grasses were dominant only in communities that were subject to long-term, continuous disturbance such as balds, shelter clearings, and roadsides. Old fields tended to have more forbs than these communities. Burn scars were dominated by *Rubus* sp., *Angelica triquinata*, *Solidago glomerata*, and tall forbs.

Differences between sites were due mainly to differences in elevation and history. Aspect and successional stage caused most of the variation between different plots on one site.

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## PROBLEMS OF REVEGETATION OF ALPINE TUNDRA

STEVENS, DAVID R.

The alpine tundra is one of the most unique resources in Rocky Mountain National Park. The restoration of human damage needs to be an important part of management in this ecosystem. Since 1932, when Trail Ridge Road was opened to the public, efforts have been made to restore the damage caused by man's activities in this area. Destruction of the tundra has been the result of activities such as road and parking area construction, trail construction, visitor trampling, and removal of earlier human intrusions. Without assistance, it is estimated to take hundreds of years for tundra areas to recover. Numerous techniques to restore the tundra have been tried, but most have failed. The objective of this study is to review past restoration efforts and, by using modern technology, test what appear to be the most feasible techniques for tundra restoration.

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PHOTOSYNTHETIC PATHWAY DISTRIBUTIONS ALONG AN ELEVATION-ARIDITY  
GRADIENT IN BIG BEND NATIONAL PARK

EICKMEIER, W. G.

Three distinct pathways of photosynthesis exist for higher plants, the Calvin-Benson cycle ( $C_3$ ), the Hatch-Slack cycle ( $C_4$ ), and the Crassulacean Acid Metabolism cycle (CAM). These pathways are different in many important respects (i.e. ecological relations) and should be important in ecosystem structure and interspecific competition for desert communities. This paper describes the distributions of these pathways along a composite elevation-aridity gradient in Big Bend National Park, Brewster Co., Texas.

The vegetation along this gradient changes dramatically due to increasing rainfall and decreasing temperature at upper elevations. The vegetation was quantitatively sampled and the pathway of each species was determined by  $CO_2$  gas exchange patterns, presence or absence of diurnal acidity changes, carbon isotope ratios, anatomical characteristics, and/or previous literature reports.

The results of this study closely follow trends hypothesized from pathway environmental relations. The CAM pathway dominated low elevations, the  $C_4$  pathway dominated mid elevations, and the  $C_3$  pathway dominated high elevations; however, there were some interesting anomalies.

I conclude that photosynthetic pathways and their different environmental adaptations and competitive abilities are important in understanding the composition and structure of desert plant communities.

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ECOLOGY OF SHORELINE VEGETATION, LAKE POWELL

POTTER, L. D.

The biogeologic setting for Lake Powell of the Glen Canyon Recreation Area and the conversion of the Colorado River to a reservoir are discussed. The relation of physiographic features to vegetation and shoreline recreational use are presented. A major problem discussed is the plant invasion of exotic species into the seasonal drawdown zone.

Tamarisk is a principal invading species and has a multitude of adaptations to overcome the adversities of a fluctuating shoreline. The relative breakdown and decomposition of native vegetation and tamarisk after submergence are discussed, as is the importance of the mantle of benthic organisms. As seedlings of tamarisk become progressively older, they are more difficult to control. The need is stressed for some shoreline management to preserve the desirable sandy shores for recreational use, rather than allowing their development into impenetrable thickets with noxious insects and with submerged off-shore masses of flooded vegetation.

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RIPARIAN ENVIRONMENTAL-VEGETATION INTERRELATIONSHIPS ALONG THE LOWER ESCALANTE RIVER, GLEN CANYON NATIONAL RECREATION AREA, UTAH

Irvine, J. R. and West, N. E.

Studies of environmental and riparian vegetation interrelationships along the lower Escalante River were conducted during 1974 and 1975. The study area included the Escalante River flood terraces between Harris Wash and Coyote Gulch.

Methods were developed compatible for wilderness use. Sixty-nine 1 x 10 meter macro-plots were taken at 23 locations. Measurements were taken of major environmental parameters thought to influence riparian vegetation: stratigraphy, soil texture and moisture, river bank angle and aspect, and height and width of flood terraces.

Canyon profile was found to be strongly influenced by geologic strata. Resistance to erosion by these strata determines canyon width, number of meanders, and river bank profile. Periodic river fluctuations and flash floods further modify the river bank profile by creating three distinct flood terraces.

Vegetation distribution was found to be roughly correlated with stratigraphy and flood terraces. The most dominant semi-aquatic species, *Scirpus americanus* and *Equisetum laevigatum* were found on soils saturated to supersaturated with water on the low flood terraces. *Baccharis emoryi* was found in the medium and high flood terraces where the Chinle Formation was exposed. Different time periods between river inundations and flash floods created significantly different population age structures for the three major tree species (*Salix exigua*, *Populus fremontii*, and *Tamarix pentandra*). Tree longevity increased from low to high flood terraces.

Population age structure differences were attributed to flooding which dynamically maintains each population. Regeneration by root suckers for *Salix* and *Populus* have a greater survival rate than *Tamarix* whose seedling source is washed away by periodic fluctuations in river level. Implications of this research are that reduction in river flow or regulation of floods would remove population equilibrium controls. *Tamarix*, without the effect of its seed source being washed away, would have a successional advantage over the other two native tree species whose densities in the young age classes are lower than that of *Tamarix*. Furthermore, tree populations would shift to an older age structure with greater density. Deleterious effects would be increased evapotranspiration and inaccessibility to river recreation. The effects of such vegetation changes on wildlife are unknown.

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# MAN'S IMPACT ON COLORADO RIVER FLUVIAL DEPOSITS WITHIN THE GRAND CANYON

DOLAN, R.\*, HAYDEN, B.\*, HOWARD, A.\*, JOHNSON, R.\*\*

The National Park Service faces several difficult issues concerning the management of float trips down the Colorado River of the Grand Canyon. The demand for float trips has increased dramatically since the early 1960's while concurrently, irreversible changes are occurring to the alluvial deposits along the river as a result of regulation of the river flow by the Glen Canyon Dam. The questions of primary importance are 1) in what manner and how rapidly are the alluvial deposits adjusting to the new river regime, and 2) is the increased use of the river contributing to the irreversible degradation of the system. This paper is addressed to the second of these questions.

Human use along the Colorado River is limited, for the most part, to the relic, pre-dam fluvial deposits colloquially called "beaches." With the new river regime these deposits are positioned well above the present high-water stage (27,000 cfs), so they are not replenished periodically as they were prior to construction of the dam in 1963. The dominant natural process is therefore aeolian.

The float-trip passengers use the river beaches for hiking, camping, and for lunch stops. At the most desirable sites between thirty and forty people camp on the beaches each night over a four to five month season. Human impact includes incorporation of camp-site litter, burial of chemically treated waste, and the direct stress associated with people walking on the vegetation and unstable sedimentary deposits.

Results of our investigations indicate that the rate of degradation at the most heavily used sites exceeds the capacity of aeolian processes to reestablish natural landscapes. Therefore, careful management of float trips is needed if these environments are to be maintained in a natural state rather than a "sand-box" like state.

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NATURAL RESOURCES IN GRAND CANYON NATIONAL PARK AND RIVER MANAGEMENT  
ALTERNATIVES ON THE COLORADO RIVER

STEVEN W. CAROTHERS<sup>1</sup>, STEWART W. AITCHISON<sup>1</sup>, and R. ROY JOHNSON<sup>2</sup>

Increasing pressure on natural resources on national park lands is a widespread problem. In some areas human impact threatens to severely alter the very resource that has made these areas suitable for inclusion in the National Park System in the first place.

Prior to 1965 fewer than 2,000 persons had navigated the Colorado River through the Grand Canyon. Not until 1967 were more than 2,000 persons/year traveling this world-reknown whitewater. Currently this popular activity is providing recreational and educational opportunities for more than 15,000 visitors/year and supports a multi-million dollar river-running business.

A limited number of beaches are available both for river-recreationists and back-country hikers. Concern over the possibility of reaching intolerable levels of impact (from recreationists) on the riparian ecosystem has led to a three year Colorado River Research Project which terminated during the summer, 1976. This paper is largely concerned with the interrelationships between the park visitor and the biota. A monitoring program has been initiated to closely follow any possible changes, or lack of changes, resulting from a new river management plan which is currently being formulated. This monitoring program will be a cooperative venture between National Park Service managers, researchers and private contractors.

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INTER-RELATIONSHIPS AMONG VISITOR USAGE, HUMAN IMPACT, AND THE BIOTIC  
RESOURCES OF THE RIPARIAN ECOSYSTEM IN BIG BEND NATIONAL PARK

David J. Schmidly, Robert B. Ditton, William J. Boer, Alan R. Graefe

The primary goal of this research was to secure detailed information concerning the actual and potential impact on the Rio Grande in Big Bend National Park (BBNP) and on associated land area ecosystems resulting from present levels of human usage.

In evaluating user patterns, all potential information systems on BBNP use were reviewed and evaluated. These included concessionaire data, ranger counts at developed campgrounds, traffic counter data, and backcountry permit data. The latter category was particularly valuable in determining how many, when, and where people used the Rio Grande corridor.

The extent of human impact was assessed by the use of a subjective site evaluation sheet which included four basic parameters and 15 different variables. The biological resource monitored was the rodent fauna, which was sampled at 18 different sites along the river exhibiting varying degrees of human impact.

The correlation coefficient statistic was used to relate total subjective impact ratings by site to annual camping use by site (man-days). Analysis revealed a significantly positive correlation, verifying that as use increased subjectively evaluated impact also increased. When impact and use data were related to biological data (i.e., rodent fauna), no significant correlations were yielded. The upshot of these two correlation analyses is that site impacts have occurred as a result of recreational use, but not to the point where ecological conditions, as indicated by the biological health of rodent fauna, are in jeopardy.

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OZARK RIVER-USE INVESTIGATIONS  
Marnell, Leo F.

During the past five years, the National Park Service has been engaged in an intensive research effort at Ozark National Scenic Riverways to secure facts about river users and assess the impacts of recreational floating on the resource. An interdisciplinary program has evolved with consideration given to water quality, physical impacts on the environment, sociological aspects of river-use, and visitor safety. Patterns of river-use have also been extensively monitored. Findings from the various studies are described and plans for use of the data in carrying capacity decision-making are discussed.

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## APPLICATION OF RESEARCH DATA TO CARRYING CAPACITY DETERMINATION

CHILMAN, K. C. AND BURDE, J. H.

Given that we have certain data or are collecting data, how will it be useful for such management decisions as carrying capacity determination for a large park area? Carrying capacity is a multi-faceted concept. Data collected will need to be organized in relation to management objectives, probably through a public review process, into a management plan.

It is often taken for granted that management objectives are already determined and readily available, when in fact they may exist only in fragmented form. This fragmentation is due to 1) changes in the basic management situation and 2) closer public scrutiny. It can no longer be assumed that objectives are well known: conscious planning (with improved data) must develop and refine new objectives.

Pre-objectives planning differs from existing planning efforts in emphasis on 1) shift from facilities development planning to carrying capacity planning for park areas, 2) orientation on planning for field unit needs as well as central office needs, and 3) uniqueness of the particular site and its management directions versus standardized unit treatments.

This emerging planning strategy calls for (as well as an improved data base) a closer liaison among researchers, planners, and managers. The need for continuing communications among the parties involved will necessitate new organizational arrangements and operating strategies.

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MONITORING EMERGENCE PERIODS OF THE SMALLER EUROPEAN  
ELM BARK BEETLE SCOLYTUS MULTISTRIATUS IN THE NATIONAL  
CAPITAL PARKS WITH MULTILURE BAITED TRAPS.

Sherald, James L.

The smaller European elm bark beetle Scolytus multistriatus (Marsh.) is the principle vector of the Dutch elm disease fungus in the National Capital Parks. Sanitation and a dormant application of the insectide methoxychlor are the major control measures for reducing the vector population. The Ecological Services Laboratory in cooperation with the U.S. Department of Agriculture, Northeastern Forest Experiment Station is evaluating beetle traps baited with the synthetic pheromone Multilure as a technique for monitoring beetle emergence periods.

During April 1975, 50 wire mesh traps (30 x 30cm) coated with Stikem Special<sup>R</sup> and baited with Multilure dispensers were installed at random throughout the Park. Traps were collected biweekly and the beetles counted. Beetles first began to emerge during the second week of May and reached the first emergence peak during the first week of June. A second emergence peak occurred in the last week of July approximately eight weeks after the first peak. The second generation was twice as large as the first. Beetles continued to be trapped until the first week of November.

Beetle monitoring with Multilure baited traps is currently being used by the Park to time a methoxychlor cover spray for the second emergence period.

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THE IMPACT OF DEFOLIATION BY GYPSY MOTHS ON THE FOREST  
AT MORRISTOWN NATIONAL HISTORIC PARK, NEW JERSEY

EHRENFELD, J.G.

In this paper I present the results of a study of tree reproduction and forest regeneration occurring around oaks that were killed during a massive gypsy moth outbreak in 1967-1969, in the mixed oak forest at Morristown National Historic Park. The infestation was intense in patches scattered throughout the Park, and minimal in the intervening areas; these areas were mapped during the infestation. No chemical insecticides were applied, and the outbreak was permitted to follow its normal course. The existing situation thus presents an unusual opportunity to assess the effects of uncontrolled gypsy moth populations on a mixed hardwood forest.

Vegetation around selected dead oak trees was sampled by measuring the percentage cover of each species along line transects. The dead oaks were chosen from regions which had suffered heavy, moderate, and very limited defoliation during the outbreak. The species composition and the similarity of the species composition to that of the surrounding stand were measured, and the tendency for the regenerating forest to restore the initial forest cover types was determined for the three kinds of areas. The overall results indicate that the gypsy moth may either retard succession, by permitting increased reproduction of early successional stage species beneath dead trees, or accelerate succession, by removing the remaining old individuals of early seral stages from a near-climax stand.

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DUTCH ELM DISEASE THERAPY IN THE NATIONAL CAPITAL PARKS -  
A PROGRESS REPORT. Sherald, James L.

Dutch elm disease (DED) caused by the fungus Ceratocystis ulmi (Buism) C. Moreau continues to be one of the most serious problems encountered by the National Capital Parks. The Ecological Services Laboratory in cooperation with the U. S. Department of Agriculture, Northeastern Forest Experiment Station is evaluating the combination of high pressure fungicide injection and pruning of diseased limbs as a practical technique for curing elms infected with DED.

During June and early July of 1975, 29 elms (average diameter at breast height 35") which exhibited wilt in 30% or less of the tree crown and from which C. ulmi could be isolated were given a trunk injection (70 psi) of MBC.HCl (methyl 2-benzimidazole carbamate hydrochloride; 3 grams/liter, 2 liters/diameter inch). When symptoms were localized in a single limb, a limb injection (6 grams/liter, 1 liter/diameter inch) was also given. All diseased limbs were pruned shortly after trunk injection.

By late August and early September only one of the treated trees exhibited further progression of DED. By July 1976, twenty trees had a recurrence of DED. Five trees displayed greater than 30% wilt and were removed; fifteen trees exhibiting less than 30% wilt were reinjected (6 grams/liter, 1 liter/diameter inch) and pruned a second time. Of 29 trees treated in 1975, nine were apparently free of DED by July 1976.

The injection/pruning program will be continued and evaluated over a 3 year period.

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## REMOTE SENSING AS AN AID TO DETECTION OF URBAN VEGETATION STRESS

Hammerschlag, Richard S.

The process of remote sensing offers great promise as a practical tool for aiding the detection of stress on vegetation in areas of high use. Besides the given virtues of large scale coverage in a short time and vertical perspective, special remote sensing techniques coupled with enhancement can provide renditions of urban type scenes exposing stressed vegetation not normally seen.

The Ecological Services Laboratory, National Capital Parks, has been working with NASA, Wallops Station to produce a remote sensing system which will assist maintenance in the management of NCP's urban parklands. Several procedures have been tested using color and color IR film/filter combinations and multispectral photography coupled with scanning microdensitometry, objective viewing and the Image 100. These procedures were largely pursued in a quest for early detection of Dutch elm disease but only minor success has resulted. There has been much greater success in detecting elms stressed due to other causes such as construction, elm scorch, leaf curl and borers. Further work is warranted to better differentiate between stress causes and to minimize errors from false positive imagery.

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## RETARDATION OF GRASSES WITH CHEMICALS

Rai, G. S., Ogra, M. S., Yatsu, L. Y.\*, Tallant, J. D.\*\*, and Sims, A. C.

Growth in grasses is a continuous process which begins in leaf primordium and then it becomes confined to an intercalary meristem. Because of this growth pattern repeated mowings are needed. During the last two decades plant biologists have been working on alternative methods to mowing which make use of the chemicals. These compounds when used as foliar spray or directly incorporated into soil in suitable concentrations arrest cell division, block synthesis of gibberellins, suppress apical dominance, and cause other metabolic changes which lead to growth suppression.

To evaluate the usefulness of commercially available compounds maleic hydrazide (1,2 dihydropyridazine-3,6 dione), Sustar 2-S [N-4-methyl-3-(1,1,1-trifluoromethyl sulfonyl amino) phenyl] acetamide and Maintain CF 125, treatments were arranged, at Chalmette National Historical Park, in Latin Square System with four replications and with four rates, that is 0, 1,000, 5,000, and 10,000 PPM based on active ingredient equivalents.

Analysis of variance of fresh yield of grass clippings, 71 days after the foliar application of the chemicals, indicated no fertility differences at 95% level among 4 larger plots or replications.

The two primary variables, that is, chemicals and rates of applications in PPM proved to be significantly different from control plots.

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## ROOT DISEASE, HAZARD, AND FOREST PROTECTION IN YOSEMITE VALLEY

Parmeter,<sup>1</sup>J. R., Jr., MacGregor,<sup>2</sup>N. J., Srago,<sup>2</sup>M., and Cobb,<sup>1</sup>F. W., Jr.

Root disease, caused by *Fomes annosus*, is prevalent in the ponderosa pine/incense cedar stands of Yosemite Valley. Trees of all ages have been killed in enlarging "centers" as the fungus spreads from tree to tree along roots. Over 100 such centers in developed sites and over 50 in undeveloped sites have been confirmed by isolation or detection of sporophores.

Monitoring (past 5 years) of mapped centers and reference to park vegetation maps (up to 40 years old) provided preliminary indication that center margins have enlarged about 2-3 ft./yr. The largest mapped center, traced back to the 1930's, now exceeds 1/2 acre and is continuing to enlarge. Evidence indicates that centers will enlarge until obstructed by treeless areas or by stands of oaks or other resistant hardwoods.

The rate at which new centers have been initiated is unknown, but over half of the centers in developed sites involve fewer than 6 trees and are estimated to be less than 20 years old. New centers have been discovered each year since studies were begun 5 years ago. The rate of center enlargement and the apparent rate of center initiation suggest that *F. annosus* will ultimately eliminate most of the pines and cedars in Yosemite Valley.

In addition to loss of forest cover, *F. annosus* decay of roots causes potential hazard to park visitors and facilities. Failure of root-rotted trees has caused both loss of life and property in the Valley. Guidelines for early recognition and removal of hazardous trees are being developed.

This intensive study of Yosemite Valley suggests that root diseases may be critical factors in the management of forest stands in high-use park areas.

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COMPOSTING - AN ATTRACTIVE AND ECONOMICAL WAY TO RECYCLE  
URBAN-PRODUCED ORGANIC MATERIALS. Patterson, James C.

There are large amounts of organic materials produced within the urban environment which have for years been disposed of through dumping. The U.S. Department of Agriculture, Beltsville, Maryland, has pioneered "static pile composting" which renders a mixture of sewage sludge and wood chips into an effective organic soil amendment. This paper deals with two associated projects underway in National Capital Parks.

The first project involves composting of raw sludge material collected from sanitary toilets along the C&O Canal. The material is possibly 95% liquid and yet is turned into a stable compost material in about three weeks. Organic materials, such as saw dust, wood chips, and Beltsville compost are used as bulking materials to provide the aeration within the piles.

The second project is centered in Rock Creek Park and is geared to recycle those organic materials which are available in excess from park operations: horse manure, leaves, wood chips, paper refuse, grass clippings and sewage sludge. It is our desire to create two or three formulations that will be used for turfgrass, shrubs and trees. These materials will then supplement the normal fertilizer and organic soil amendments.

There are many uses to which these compost materials can be directed such as mulches, picnic and playground soil stabilization, a planting bed amendment, trail stabilization, supplemental turf fertilizer, etc. It is our feeling that the composting system mentioned will help National Capital Parks solve their organic "waste" problems and yet help supplement our needs for fertilizers and organic soil amendments.

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UTILIZATION OF URBAN PRODUCED WASTES FOR SOIL  
RENOVATION. Short, John R.

The traditional methods of disposal of urban-produced wastes, in view of the rising cost of fertilizers, soil conditioners, desirable topsoil, and alternate methods of disposal of these wastes, cannot now be considered practical. Other methods of disposing of these organic wastes must be developed. One such method is composting, developed by the U.S. Department of Agriculture, Beltsville, Maryland

National Capital Parks, in addition to being concerned with the increasing cost of fertilizer, is interested in actively promoting the recycling concept. These concerns coincided with the decision to create a park in the site of former World War I temporary buildings, and it was decided to utilize organic wastes in the preparation of the soil. The wastes utilized in the preparation of Constitution Gardens were sewage sludge composted with woodchips, and leaf mold. These materials were mixed and incorporated with the subsoil already present, and a small amount of topsoil was applied to the surface. These materials have generally provided good results, although some problems still need to be resolved.

Another project which will utilize urban wastes is the renovation of the site of the Folklife Festival. The Festival itself will run for three months, and the entire site has had a broadcast application of woodchips. In order to reestablish turf at this site, composted sludge and the woodchips already present will be incorporated into the soil to provide an improved rooting medium for turf.

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## USE OF COMPOSTED SEWAGE SLUDGE FOR ESTABLISHMENT OF TURFGRASS

ANGLE, J.S., WOLF, D.C.<sup>1/</sup>, and HALL, J.R.<sup>2/</sup>

Plant response and changes in soil physical and chemical properties upon addition of composted sewage sludge are reported.

A Sassafras sandy loam soil was amended with composted sludge at rates of 0, 90, 180, 360, and 720 mT/ha and each main plot was divided into two sub-plots. The sub-plots were sodded with a Kentucky Bluegrass mixture or Kentucky 31 Tall Fescue. Four months after sod placement, sod pulling strength was measured to evaluate the ability of the sod to re-root into the compost amended soil. Kentucky Bluegrass exhibited sod pulling strengths of 709, 969, 875, 793, 819 kg/m<sup>2</sup> at compost rates of 0, 90, 180, 360, and 720 mT/ha, respectively. At the same compost rates, Kentucky 31 Tall Fescue had sod pulling strengths of 533, 721, 635, 456, and 436 kg/m<sup>2</sup>, respectively.

Foliar analyses of turfgrass four months after sod placement on the compost amended soil showed increased P concentration in both turfgrasses with increased compost addition. Compost additions of 0, 90, 180, 360 and 720 mT/ha resulted in N contents of 3.95%, 3.73%, 4.45%, 4.45% and 5.08%, respectively for Kentucky 31 Tall Fescue. The N concentration of Kentucky Bluegrass was not influenced by compost additions.

Soil samples were collected at a depth of 0-3 cm four months after sod placement. Compost addition resulted in a consistent decrease in soil bulk density and an increase in percent soil moisture.

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SOIL COMPACTION - EFFECTS ON URBAN VEGETATION  
Patterson, James C.

The urban environment imposes severe stress upon vegetation. The problems are many, and interactions common, making simple solutions difficult. This paper on urban soils discusses basic soil physics and soil chemistry, reviews existing literature, and describes several research efforts in Washington. Particular emphasis is placed on soil compaction and ways to minimize its deleterious effects upon vegetation.

Natural soils contain a volume of pore space of 50% or more while urban soils are generally highly compacted with pore space volume of from 13 to 35%; this condition in itself creates severe plant problems. The densities of urban soils are generally quite high due to heavy-use, causing severe plant stress.

We are testing various materials which assist in reducing compaction while increasing water holding capacity. Some of these materials are considered lightweight aggregates while others are urban-produced organic materials. Each has value as a soil amendment.

Our principal hypothesis is that a soil amendment should assist in reducing compaction for the long-term, particularly as it relates to tree growth. Secondly, a soil amendment should be economically feasible and yet available for use.

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MODIFICATION OF BULK DENSITY ON SILTY LOAM AND SANDY  
LOAM SOILS IN WASHINGTON, D. C. Short, John R.

The soil present in an urban environment undergoes severe compaction, which causes problems for the urban planner. Soil, when compacted sufficiently, is difficult to utilize as either a landscaped area or a recreation area. Compacted soil limits water intake into the soil, gaseous exchange with the atmosphere, root penetration and plant establishment. Because urban soil is used for recreation and planting purposes, a method must be found to overcome these deficiencies.

Several amendments, both organic and inorganic, were applied to a silty loam and a sandy loam soil in varying rates. The amendments used were sintered fly ash, expanded slate, coarse construction sand, and sewage sludge as an organic additive.

Bulk density, infiltration rate, and pore space are the principle parameters used to determine the various degrees of compaction of the test plots. Bulk density was determined using the clod method, infiltration rates were determined using double ring infiltrometers, and pore space was calculated using the values for bulk density and particle density previously determined.

Incorporating the hard, inorganic amendments into the soil, will result in increased pore space. This increase in pore space will allow a more rapid water intake rate, better oxygen-carbon dioxide relationships in the soil atmosphere, and easier penetration of the soil matrix by plant roots.

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USE OF DREDGED MATERIAL FOR MARSH REESTABLISHMENT AT  
DYKE MARSH. Hammerschlag, Richard S.

Dyke Marsh is a fresh water tidal marsh located in the Potomac estuary south of Alexandria, Virginia. This area has received various types of intervention by man including diking for fishing and land reclamation, dredging for sand and gravel, filling by barge and truck as well as some modification for recreational purposes. The Park Service is currently considering various alternatives for managing the marsh area. One of the more promising alternatives considers the practicality of restoring portions of the marsh. The potential for using dredged material at Dyke Marsh as a readily available material has been thoroughly analyzed by several units of the Waterways Experiment Station (WES), Vicksburg, Mississippi. Chemical/physical analyses of the potential source material from a shoal in the Potomac River Channel, the marsh and disposal areas were made. Engineering feasibility studies were run to include: dike types and design, location of the first or demonstration cell, erosion/water vector forces in the marsh area, alternate filling techniques, etc. An environmental assessment is being written which includes collected data on the standard topics of wildlife, vegetation, topography, archeology, etc. It is anticipated that the information and actual completion of the demonstration cell will provide good precedent for further restorations and Dyke Marsh and other similar areas around the country.

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## EFFECTS OF PEDESTRIAN TRAFFIC ON SAND DUNE VEGETATION

NICKERSON, NORTON H.

Use of publicly-owned natural areas for recreational purposes is clearly increasing; effects of this intensifying use on the vegetative cover in ecologically fragile areas as often highly destructive and rather abrupt in their appearance.

For the past five years effects of pedestrian traffic have been studied at the Province Lands Dunes in the Cape Cod National Seashore in an attempt to develop an understanding of the responses of the major dune-binding sandgrass, Ammophila breviligulata, under various use-pressures, and to develop specific recommendations to the Seashore on how the dune areas may be used without being destroyed.

Plant studies reveal that spread by rhizome formation is not pronounced at edges of grass fields; that buried (but dead) vertical stems are more important to plant survival than horizontal surficial roots; and that vulnerability to foot traffic varies with time of growing season. Shoe traffic is 10 to 20 times more destructive than barefoot traffic in comparable areas. Methods of measuring degrees of plant destruction and recovery in the field have been developed.

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OFF-ROAD VEHICLE IMPACT ON A SALT MARSH IN CAPE COD NATIONAL  
SEASHORE, MASSACHUSETTS.

Brodhead, J. M. B., and Joseph DiMaio

A three year study of a heavily impacted salt marsh on Cape Cod, Massachusetts, was initiated in 1974. The marsh is relatively young, having developed typical salt marsh vegetation in the last one hundred years. Aerial photography has documented vehicle traffic in the marsh at least as early as 1938. At present, approximately half of the intertidal portion of the kilometer-square marsh is bare sand. Most of the vegetated portion is a *Spartina alterniflora* community with only a small fraction of *Spartina patens* at higher elevations.

The objects of the study were as follows: to determine the amount of sand flat which has been artificially maintained in that state by driving; the potential natural vegetation of these areas; the amount of driving required to maintain the bare sand flat; the most likely successional sequence to full recovery in impacted areas; the feasibility of enhancing the recovery of bare areas through modification of tidal flux, fertilizer and plantings.

Findings to date have confirmed the hypothesis that much of the bare sand flat in the marsh is unnatural and capable of rapid recovery when protected from driving. Very low densities of traffic early in the growing season are capable of maintaining bare areas in the marsh indefinitely. Factors influencing recovery include elevation and proximity to shifting sand, seed source, or vigorously advancing rhizomes.

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## EFFECT OF OFF-ROAD VEHICLE TRAFFIC ON BEACH AND DUNE VEGETATION

Brodhead, J. M. B., Joseph DiMaio, Robert Zaremba and Deborah Elmer

This paper reports on work in progress on the beaches and dunes of Cape Cod National Seashore, Massachusetts. Since 1974, a number of long term impact and recovery plots have been established in plant communities on unstabilized and stabilized sand.

Experiments included subjecting test plots to controlled driving at various levels; to uncontrolled driving by the general public; and to no driving at all. Estimates of vehicle impact on the vegetation and its subsequent recovery were made by following changes in substrate elevation, and by vegetation counts, mapping, and measurements of biomass and percent cover.

The dominant plant of the beaches and dunes is *Ammophila breviligulata*. This colonizes the upper beach both by sprouting of new plants from fragments washed ashore and through underground rhizomes which spread from established plants. Summer growth rate of these runners averages 2 cm/day. 100% of the runners in an experimental plot were destroyed by 100 vehicle passes.

Season of impact seems to make little difference in above-ground biomass reduction of foredune or dune, but recovery after impact is much faster in the foredune. There is a greater annual sand accumulation in the foredune.

Recovery after impact was markedly slower in the stabilized sand communities. *Hudsonia* and *Deschampsia* were reduced to lowest levels after 50 passes and recolonized by seeds. *Arctostaphylos* is initially more resistant, but after 300 passes, all three communities were at the same low biomass levels. *Arctostaphylos* recolonized by above-ground runners.

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EFFECTS OF THE PREDATOR *POLINICES DUPLICATUS* (GASTROPODA) AND OFF-ROAD VEHICLES ON THE *MYA ARENARIA* (PELECYPODA) POPULATION IN HATCHES HARBOR, CAPE COD NATIONAL SEASHORE, MASSACHUSETTS.

Wheeler, Nancy R.

This study compares mortality induced on the *Mya arenaria* (soft shell clam) population by varying levels of off-road vehicle (ORV) driving with mortality induced by the natural predator, *Polinices duplicatus* (clam drill) in Hatches Harbor near Provincetown, Massachusetts.

During the summers of 1975 and 1976, ORV impact levels of fifty passes per day for a three week period and five and twenty-five passes per week for a ten week period were imposed upon *Mya* individuals. These clams were numbered, measured, planted in rows, and recovered at the end of experimental driving periods. Growth rates of survivors and mortality were recorded. Population density of the naturally occurring *Mya* population and bivalve species composition were estimated by random sampling throughout the study area.

*Polinices duplicatus* individuals were collected in Hatches Harbor from June through October 1976. Shells of individuals were marked and measured, prey species and size (if the animal was feeding) were recorded, and individuals were released. Growth rates, and species preference will be noted.

Though this study will not be concluded until October, 1976, present trends indicate that *Mya* mortality caused by heavy ORV driving is more destructive in form than the natural predation of the *Polinices* population; this is due to the size (age) preference selection of the snails which choose immature clams, while ORVs indiscriminately destroy reproductively active and immature individuals, as well as compact the sediments which inhibits the flow of water carrying oxygen and nutrients to the filter-feeding *Mya*.

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## THE EFFECTS OF OFF-ROAD RECREATIONAL VEHICLES ON SHOREBIRD POPULATIONS

Blodget, Bradford G. and Dianne Smith

The highly cryptic nests and young of beach-nesting seabirds, particularly terns, render them particularly vulnerable to disruption during the nesting season. The effects of ORV traffic on these birds has never been adequately documented. Also, concern has grown that driving on tidal flats may have adverse long-range effects upon flocks of migratory shorebirds that utilize these areas for resting and feeding.

Our findings at Cape Cod National Seashore have tended to show that with complete closure of nesting areas and stepped-up wardening, hatchability of Least Tern (*Sterna albifrons*) eggs remains excellent, even despite proximate ORV traffic and associated high levels of human disturbance. The histories of 113 nests were followed in 1975. Disturbance and distribution studies, detailed habitat analysis, censusing, and an historical analysis of the regional population are underway.

About 455 and 551 pairs of Least Terns were censused on the Lower Cape in 1975 and 1976, but it is not possible to conclude whether this increase reflects relocated birds or actual new recruits into the breeding pool. Productivity has been poor at most colonies due to washouts and incessant fox predation. With protective measures in effect, there has been little direct loss of eggs and chicks due to wheels.

In 1975, shorebird study plots on the tidal flats were experimentally impacted by driving over them known numbers of times. Shorebird foraging behavior was then observed to determine if the birds would reject this area, due perhaps to a depauperated infauna. *Calidris* sandpipers and dowitchers showed a significant preference for non-impacted areas. However, plovers preferred driven-upon areas, apparently in response to food items turned up by wheels.

These observations are continuing in 1976. In addition the plots themselves are being sampled for infaunal populations.

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THE EFFECTS OF OFF-ROAD VEHICLES ON THE GEOMORPHOLOGY OF DUNES IN THE  
CAPE COD NATIONAL SEASHORE

Leatherman, S. P., Hamilton, J. A. and Carey, W. L.

The dune system in two contrasting areas within the Seashore are being studied to determine the areas where vehicular traffic may cause significant environmental change. The introduction of the over-sand vehicle appears to have resulted in vegetative denudation and consequent lowering of portions of the stabilized Provinceland and dunes. Sand tracer studies were used to quantify the volume of sand displaced downslope due to propulsion of vehicles. Control areas were monitored to determine the natural rates of sediment movement for comparison with the ORV's effects.

In contrast to the prograding shoreline of Race Point in the Provincelands, the dunes at Nauset Spit are scarped on their seaward face. Barren washover flats and smaller washover fans are present along the length of the spit. Observational data indicate that many of the smaller dune breaches are indeed man-made. In addition, vehicular traffic over existing washovers prevents revegetation of these barren regions and establishment of dune vegetation. The formation of dunes would tend to prohibit most overwashes except those associated with extreme events. Field sites, both control and impact areas, have been selected for continued surveying in order to evaluate the relative roles of overwash and dune building, and the impact of vehicles on these processes. These studies should determine if substantial long-term disruption of natural geomorphic processes occurs as the result of recreational off-road vehicles in the coastal system.

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THE IMPACT OF THE EUROPEAN WILD BOAR ON NATIVE PLANT COMMUNITIES  
IN GREAT SMOKY MOUNTAINS NATIONAL PARK

Bratton, Susan Power

Since the European wild boar (*Sus scrofa* L.) entered the Great Smoky Mountains National Park in the 1940's, the rooting activities of this exotic species have disturbed a number of native plant communities. The most extensively damaged areas are in gray beech forest and high elevation hardwood forests with understories of mesic herbs. Most of the rooting activity in these communities occurs in May and June. Herb cover may be reduced to less than 5% of the expected value. The number of herb species per sample plot may also be reduced and poisonous plants may increase in relative cover.

In the winter, successional tulip tree and tulip-silverbell forests are usually the most intensively rooted by hogs, although both oak and pine forests are also locally disturbed. On the grassy balds, hogs in search of starchy rhizomes or insect larvae root around the bases of the shrubs and roll the grass turf.

The herb cover on the grassy balds and in the open tulip forests regenerates more quickly than that under gray beech forest or other types with a dense canopy. Hog rooting on the balds favors forbs like *Potentilla simplex* over grasses. Hog rooted areas in tulip forest also tend to support weedy forbs such as *Ambrosia* spp. and *Dioscorea batatas*.

Hog rooting changes the structure of the soil surface and may result in surface erosion.

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GRASSY BALDS IN GREAT SMOKY MOUNTAINS NATIONAL PARK:  
HISTORY AND VEGETATIONAL SUCCESSION

LINDSAY, MARY

Local oral tradition suggests that at least some of the grassy balds of Great Smoky Mountains National Park were cleared by white settlers. Regardless of the reason for the original removal of trees, the balds became and remained grassy because of heavy grazing. Since the establishment of the National Park and the consequent cessation of grazing, all balds have been invaded by forest tree species.

All grassy balds were certainly much enlarged by continued grazing and cutting. Grazing was so intense that establishment of woody seedlings was prevented, and the forests on top of the main ridge in the western half of the Park consisted of widely spaced large trees with a grassy understory. Fire was not an important factor in bald maintenance.

The area free of trees has decreased by over 50 percent on most balds, succession being faster at lower elevations. *Vaccinium* spp., *Rhododendron* spp., *Crataegus* sp., and *Amelanchier laevis* are the earliest invaders. Species dominant in the surrounding forests such as *Quercus rubra*, *Betula lutea*, *Fagus grandifolia*, and, at higher elevations, *Abies fraseri* and *Picea rubens* are well established. Ring counts show that most of the trees became established after the cessation of grazing.

The grassy balds are not naturally self-maintaining communities. Without management, they will succeed to forest in 30 to 100 years.

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DECOMPOSITION OF FILTER PAPER AND NATIVE HERBAGE AT FIVE MEADOW  
SITES IN SEQUOIA NATIONAL PARK, CALIFORNIA

RATLIFF, R. D. AND WESTFALL, S. E.

How much grazing a mountain meadow can stand probably depends on the rate of herbage decomposition. Information on decomposition rate for the meadows of the Sierra Nevada of California is scant. To help fill the gap, five meadows on the Sequoia National Forest were studied during a 3-year period (1972-1975) to determine an index to decomposition. Weight losses from filter paper and from native herbage--buried and unburied--were measured. Native herbage samples provided a more accurate index to decomposition than did filter paper. Herbage remains are naturally deposited on the soil surface. Therefore, rate of decomposition for unburied herbage is probably more accurate than that for buried herbage.

The range of yearly weight losses and standard statistical errors, by type of sample, was: (a) buried herbage--losses, from 48 to 83 percent; errors, from 1.4 to 4.7 percent; (b) unburied herbage--losses, from 49 to 78 percent; errors, from 1.4 to 5.2 percent; (c) buried filter paper--losses, from 22 to 91 percent; errors, from 1.9 to 10.4 percent; and (d) unburied filter paper--losses, from 4 to 60 percent; errors, from 2.1 to 9.1 percent.

Between year differences in decomposition rates occurred at only one site with unburied herbage, but year differences were significant at four sites with buried filter paper. Buried herbage was affected by year on two sites, and unburied filter paper was affected on three sites.

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ASPEN UTILIZATION BY LARGE HERBIVORES IN ROCKY MOUNTAIN NATIONAL PARK

OLMSTED, C. E.

The decline of aspen (Populus tremuloides Michx.) on elk winter range has been reported from several National Park Service administered areas in the Rocky Mountains. This paper reports on patterns of aspen utilization and population dynamics in an area that undergoes heavy browsing by both elk (Cervus canadensis) and mule deer (Odocoileus hemionus).

Thirteen permanent transects were established in aspen stands on the lower eastern drainages of Rocky Mountain National Park. The transects were oriented perpendicular to and crossed the boundary of stand development when such boundaries were evident. The transects extended from the margin to the apparent center of each stand. They were each 1 m. wide by 2 m. high and ranged in length from 20 m. to 80 m. Transects were resampled at monthly intervals during the 1975-76 browsing season. The winter history of 7242 twigs of the previous season's growth was followed. Condition, basal diameter, upper diameter, total length, non-viable length, and number of buds were recorded for each twig on each visit.

The control stand, within an exclosure, experienced a 3.8% loss in twig volume, primarily due to abscission of spur shoots. Comparison of the data on a same stand basis with aspen density results collected in 1970 and 1973 indicate the following: an 8.3% increase in aspen/acre is associated with a 19.7% loss in twig volume, a 5.0% decrease in aspen/acre is associated with a 34.6% loss in twig volume, a 27.0% decrease in aspen/acre is associated with a 70.6% loss in twig volume. Twig volume losses in all other stands sampled ranged from 43.0% to 78.9%.

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LAND USE HABITS AND CHANGES IN VEGETATION ON EASTERN OREGON  
RANGELANDS--AN HISTORICAL PERSPECTIVE

SHINN, D. A. AND STARKEY, E. E.

Because National Park Service lands are neither isolated ecosystems nor segregated land management units, a regional perception of past and present land use habits is important. Data concerning changes in vegetation through time in the sagebrush-bunchgrass habitats of eastern Oregon have been acquired for potential application at John Day Fossil Beds National Monument, Oregon and at Lava Beds National Monument, California.

Two environmental factors are of principal concern in this study: 1) fire (and fire suppression) and 2) livestock grazing. Three research techniques were used to measure the influence of these factors on the sagebrush-bunchgrass environment: 1) Ethnographic and historical literature has been investigated to outline changing resource use habits occasioned by the shift from Native American to European proprietorship. Aboriginal use of fire is compared with post-settlement fire use and suppression. Intensities of livestock grazing through time are reviewed and correlated with historical information on changing range conditions. 2) Early photographs of rangelands in eastern Oregon, dating to the late 1880's, have been gathered. Selected scenes have been relocated and current photographs taken. The vegetation pictured in each "before-and-after" set of photographs has been compared. Changes in vegetation are discussed. 3) Informal interviews with land managers, ranchers and "old timers" have been conducted to determine popular range management habits and perceptions at present and in the recent past.

Data obtained through these three techniques have been integrated to indicate: 1) changing human activities affecting the lands surrounding John Day Fossil Beds National Monument and Lava Beds National Monument; and 2) the influence of these activities on the vegetation of those areas.

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ALPINE AND SUBALPINE VEGETATION UNDER THE INFLUENCE OF NON-NATIVE MOUNTAIN GOATS, OLYMPIC NATIONAL PARK

OLMSTED, INGRID, C.

The alpine/subalpine vegetation of the geologically complex Klahhane Ridge in Olympic National Park was mapped and studied with regard to the influences of non-native mountain goats.

In the northeastern portion of the Olympic Mountains, Klahhane Ridge is a west-east trending, mostly volcanic mountain. Steep topography and precipitous rock formations are basic habitat factors which have influenced the varied subalpine/alpine plant communities. Five habitat types have been recognized. Plant communities will be described within these habitats. A vegetation map of the ridge will be presented.

Mountain goats (Oreamnos americanus), introduced in the late 1920's, have reached a population size that has affected the vegetation. Various types of influences from feeding to trampling to bedding and dust-bathing have been measured. Ratios of vegetated/unvegetated goat-used areas have been determined and will be compared to similar vegetation types that are little or not at all used by goats. Cover and density measurements were made of most plant species used by the mountain goats. Permanent plots have been established for monitoring changes and succession.

Soil bulk densities were determined for all habitat types used by goats and compared to those not used by them.

Five endemic plant species of Olympic National Park grow on Klahhane Ridge. Their status and condition will be reported.

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## SUCCESSION FOLLOWING GOAT REMOVAL IN HAWAII VOLCANOES NATIONAL PARK

MUELLER-DOMBOIS, D.

A rapid early plant succession was initiated following goat removal from the seasonally dry coastal lowland. The trend was first discovered by experimental goat displacement in exclosures and now is occurring over a much wider territory.

Under high goat pressure, much of the area was covered by a sparse annual grassland (of *Eragrostis tenella*) with exposed patches of dusty soil and rock. Now the grass cover has thickened and changed in species composition and in many places is arrested in a chamaephyte stage. This stage is characterized by a prevalence of perennial bunch grasses (*Rhynchelytrum repens*, *Hyparrhenia rufa*) and by thick mat-forming grasses (*Melinis minutiflora*, *Cynodon dactylon*), which are interspersed with low-growing shrubs (*Indigofera suffruticosa*, *Cassia leschenaultiana*, *Waltheria americana*). In some places, native herbaceous vines (*Canavalia kauensis*, *Ipomoea congesta*) have overgrown the grasses and shrubs resulting in a lush vegetation cover. Depending on substrate differences and seasonal rainfall variations, these life forms are now constantly shifting in quantity, indicating a temporary dynamic equilibrium. This arrested succession is caused by a lack of tree seeds, the supply of which was exhausted by the century long devastation by feral goats.

Two exotic, taller-growing woody plants (*Leucaena latisiliqua* and *Ricinus communis*), both with an enormous seed-producing potential, are now invading the chamaephyte stage in a few locations. If this process is not closely checked, this area will convert rapidly into an undesirable thicket with very low species diversity. At the present time, these two weed-tree species form only a few small colonies in the vast area of this coastal lowland.

As step 2 in the ecosystem restoration program of this formerly goat-infested territory, these two exotic tree-pests should be monitored for elimination at very frequent (preferably monthly) intervals. As step 3, a few strategically located seed source centers should be established by planting (in aggregation) native dry-zone tree species (such as *Canthium odoratum*, *Diospyros ferrea*, *Erythrina sandwicensis*). The seed source for these centers should be obtained from within an approximate three-mile limit of the formerly goat-infested territory.

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THE USE OF UNIFORM ECOSYSTEM PARAMETERS TO CHARACTERIZE  
NATURAL AREAS

SHEA, G. BRADFORD

With increases in pressure from human society, it is becoming increasingly important to make decisions as to the preservation of valuable natural areas. Decisions regarding such preservation must result from planned, quantifiable investigation of natural values. Ecological parameters such as species diversity, successional age, biomass and productivity can provide keys for such quantification.

Studies of wetland and forest natural areas for the U.S. Park Service's Natural Landmark Program in Maryland and Virginia have revealed that several important ecological parameters can be assessed quickly and with rather simple tools. The plant community can be assessed directly by sampling, weighing and use of forestry tools such as increment borers and altimeters. Faunal biomass, diversity, productivity and standing crop can often be assessed from local information sources and a knowledge of the literature. Finally, combination of plant and animal components of the ecosystem can give important information on food availability, habitat value and overall health of the ecosystem on a long term basis.

Integration and quantification of these diverse factors provides a basic challenge for comparing values of different ecosystems. Differing types of wetland and terrestrial systems can only be compared when information is available on a large number of floral and faunal groups. This information is lacking for most natural areas and must be extrapolated from existing data.

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BIOLOGICAL MONITORING IN UNESCO BIOSPHERE RESERVES WITH SPECIFIC  
REFERENCE TO THE GREAT SMOKY MOUNTAINS NATIONAL PARK<sup>1</sup>

Johnson, W. Carter\* and Susan Power Bratton\*\*

A system of reserve-wide and special purpose permanent sample plots is suggested to monitor biotic changes in those National Parks which have been designated as UNESCO Biosphere Reserves.

Biological monitoring is a major thrust of the currently expanding UNESCO Biosphere Reserve Program. Since many National Parks have recently been included in the U. S. set of Biosphere Reserves, a unified biological monitoring system would be optimal to serve the needs of both the Parks and the UNESCO Program.

We propose that a system of permanent sampling plots be established to monitor several types of biological change in such regions. A reserve-wide network of plots remeasured at 5-10 year intervals would characterize major directions of change caused by wide-ranging phenomena such as natural succession, disturbance patterns (e.g., windthrow, fire) and the migration of altitudinal limits of vegetation zones in response to climatic change. Smaller sets of special-purpose plots would monitor changes occurring at a more local scale (e.g., response of biota to automobile emissions concentrated along roadsides). Easily measured biological variables should be selected for measurement and ultimately correlated with environmental data to test various hypotheses of change.

Time-series data such as those collected from such a plot system can be used to construct probabilistic simulation models of landscape dynamics. These models will be useful in predicting biotic changes and in prescribing management alternatives.

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<sup>1</sup>Research sponsored by Union Carbide Corporation for the Energy Research and Development Administration.

A METHOD FOR EVALUATING LAND AREAS FOR NATIONAL PARK AND NATURAL AREA STATUS.

Petrides, George A.

A checklist is developed against which to evaluate the status and suitability of areas planned for permanent nature reserve status. Area objectives are appraised and an analysis is made of whether provisions for both nature preservation and public use are adequate or excessive and whether adverse land use is properly anticipated and controlled. Appraisal of overall achievements in meeting objectives and in monitoring conditions is possible from use of the check-sheet procedure.

Application of the method is made to the national parks and reserves of one nation.

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## ASSESSMENT METHODOLOGIES FOR PROTECTED BIOTIC SPECIES

BOONE, C. J.

The Endangered Species Act of 1973 has had and will continue to have far-reaching effects upon the assessment process for identifying environmental impacts on the federally and state-protected species. As a result of attempts to quantify, as well as identify, adverse impacts on floral and faunal species at a number of construction and mining sites, a graphic matrix was developed. This matrix will be presented and suggestions for utilizing it in ways that meet the legal constraints will be discussed.

As an impact assessor, the author has reviewed a number of methodologies that are directly or indirectly applicable to the protection of endangered and threatened species. Three procedures were deemed suitable for the development of the matrix. One concerned the geographic distribution, critical habitat requirements, and land-use categories of a given protected species. Another was a procedure based on the status of the species in the natural extinction process. And the third was a method offering a quasi cost/benefit scale that can be used to identify those species in need of protection because of certain social or physiological components in their ecosystems.

From efforts to apply the matrix to biological assessment it has become apparent that an interdisciplinary approach is the most acceptable method for conducting the assessment process, considering all the federally imposed legal restraints.

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MOUNTAIN MEADOW MANAGEMENT AND RESEARCH IN SEQUOIA AND KINGS  
CANYON NATIONAL PARKS: A REVIEW AND UPDATE

DeBenedetti, Steven H. and Parsons, David J.

Mountain meadows of the southern Sierra Nevada have been subjected to continuous and concentrated human impact for over a century. This report reviews the history of this impact, analyzes management steps which have been taken to alleviate it and presents recent findings on the present status and future needs of the meadow ecosystem.

Large numbers of domestic sheep and cattle first invaded the High Sierra following the droughts of the 1860's. Accounts of the long-lasting destructive impact of these livestock on the meadow ecosystem are reviewed. Sheep grazing was phased out in the present day Parks through Federal legislation by 1900. Limited permit cattle grazing has continued. Additional local impact to the Parks' meadows has continued this century through the recreational use of pack and saddle stock.

Since about 1950 specific efforts have been made to protect and rehabilitate the Parks' meadows. Recovery from early grazing impact and the effectiveness of later management activities have been periodically evaluated. The most recent study (1973-1974), as reported here, has found Park meadows, while still showing such scattered signs of past impact as ground cover disturbance, trail scars, and lodgepole encroachment, to be generally in an improved condition. Much of the recovery identified is traced to specific management activities. Recovery of specific meadows is evaluated by revisiting areas studied by previous investigators. Finally, efforts are made to identify current problem areas or activities and to establish a baseline for future studies.

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WILDERNESS PROTECTION IN THE HIGH SIERRA: EFFECTS OF A  
15-YEAR CLOSURE

Parsons, David J. and DeBenedetti, Steven H.

Increasing use of the high elevation backcountry of the Sierra Nevada has led to a growing concern over how to best manage these areas to preserve natural conditions while at the same time permitting public use. This paper reports on the impact and effectiveness of a 15-year closure of a once heavily used subalpine lake in Kings Canyon National Park.

Concern over visitor impact led to Bullfrog Lake being closed to all camping and stock use in 1961. Recovery since that time has been evaluated by comparing the area with heavily used sites at Charlotte Lake and a comparable undisturbed subalpine forest community also within the Kearsarge Basin.

Analysis within the once heavily used campsites at Bullfrog Lake showed an average accumulation of litter and duff of 2.28 cm. This contrasts sharply with the bare soil found in the heavily used sites at Charlotte Lake, yet is still less than the buildup found in the comparable undisturbed forest. Soil compaction was measured and shown after 15 years of protection to approximate that found in the undisturbed forest. The accumulation of nearly 1.5 metric tonnes/hectare of fine fuels (including twigs and branches up to 7.5 cm in diameter) under the forest community at Bullfrog Lake also showed marked recovery over the heavily used site but was still less than that found under the undisturbed forest. Public acceptance of the need for use restrictions to protect such areas has been encouraging.

Indications are that after 15 years of closure the forest community and campsites around Bullfrog Lake have shown noticeable recovery. However, due to the high elevation and consequent slow growth rates the area will require additional time to regain the characteristics of an undisturbed subalpine forest.

The information gained from this study is analyzed in terms of its effectiveness in evaluating various backcountry use restrictions.

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## THE HALEAKALA CRATER ECOSYSTEM

SMITH, CLIFFORD W.

The Haleakala Crater Ecosystem is a severely disturbed and depauperate version of its former unique environment. Grazing by cattle and goats and the introduction of exotic weeds are responsible, yet few of the endemic species have become extinct.

Haleakala Crater is the confluence of two major erosion valleys which were partially filled by later volcanic activity. On the northern and eastern crater slopes is tropical rain forest with *Metrosideros* as the dominant species and on the southern and western slopes are mixed Hawaiian dryland forests. Within the crater, the dominant vegetation is a high-elevation scrub which nearly always consists of *Vaccinium* and *Styphelia* with or without *Sophora*. The principal determinant of the type of vegetation is rainfall, except above 3,000 m. where temperature is more important. However, in drier areas the age and type of substrate determine plant distribution. The vegetation has been severely disturbed at one time or another by cattle, goats, pigs and man for at least the past one hundred years. Most of the endemic flora and fauna have survived including many species found only on Haleakala. However, the continuous severe grazing pressure by goats, rooting by pigs, and the disturbance and weeds introduced by man are preventing the natural recovery of the ecosystem. Current evidence suggests that even when the goats are excluded from the Park, the recovery rate will be very slow.

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Baseline ecological studies and planning in Apostle Islands National Lakeshore.

Brown, R. T., Linn, R. M., Kowalski, W. L., Larsen, W. C., Schulz, R. A., Blank, L. G., Dobie, R. W., & Patzoldt, K. R.

Ecological studies of the plants, animals and soil have been completed on Bear Island and are in progress on three nearby islands, Rocky, Raspberry and York. Information obtained is being used in the drawing of a management plan for this newly authorized National Lakeshore.

Maps have been prepared showing vegetation types, animal ranges, soils, abandoned glacial lake shorelines, depth to bedrock, and soil limitations for paths and trails, for campsite and picnic areas, and for septic tank disposal fields.

In addition to the maps, species lists of plants with relative abundance in various habitats have been prepared. Rare or endangered species have been carefully noted and located. Similar lists of birds and mammals have also been developed. Comparisons between islands and within each island of both the plant and animal populations and explanations for the obvious differences have been made.

By using the newly available maps together with previously existing topographic sheets, better planning for the development of the park and monitoring of changes, man made or otherwise can be carried out.

In summary, we have carried out basic ecological and taxonomic surveys, suggested what limitations must be considered in the recreational development and management, and have provided much information which can be used by the interpretive staff.

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AN INVENTORY OF THE BIOTA OF LAKE MEAD NATIONAL RECREATION AREA

Douglas, Charles L., and Niles, Wesley E.\*

For the past two years biologists from the University of Nevada, Las Vegas and its affiliated National Park Service Cooperative Unit have been engaged in a survey of the biota of Lake Mead National Recreation Area. The study is concerned with a basic inventory of all plants and animals (excluding fish and insects) which occur within the boundaries of the 2500 square mile Recreation Area. Data are being collected on the occurrence, relative abundance and distribution of each species. Results are being published in a series of publications treating the bibliography and separate volumes on the biotic categories, viz.: plants, amphibians, reptiles, birds and mammals. The volumes on biota include distributional maps for each recorded taxon. The study represents a fundamental approach to the role of research within the Recreation Area. The accumulated data base will identify areas requiring additional research and will serve as a guide for an intelligent direction of future endeavors.

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RESOURCE MONITORING, CHIRICAHUA NATIONAL MONUMENT, ARIZONA

LUKENS, W. M. AND MOIR, W. H.\*

Scientists and managers have common interest knowing causes and rates of resource change in National Parks. At CNM a system of vegetation and soil measurement established in 1974 provided quantitative basis for: 1) describing existing vegetation and soil conditions and trends, 2) procuring a baseline data set against which natural succession can be measured, 3) identifying areas of human impact and determining if deleterious or irreversible resource damage may result, and 4) helping decide if policies of visitor or maintenance regulation or use-limitations should be implemented.

The monitoring system employs vegetation and soil measurement techniques commonly used by plant ecologists, namely sets of quadrats, transects, and photographic sites at permanently established locations in different park zones. These zones are road and trail corridors, research natural areas, high-density visitor sites, and wilderness. Care must be taken when reading quadrats to minimize location effects, worker bias, and observational disturbances. These "apparent" measures of resource change are artifacts of the monitoring system and must be distinguished from "real" effects caused by natural or human impacts.

The monitoring system detects small magnitudes of resource change long before trends become subjectively apparent to casual observation. Scientists can measure vegetation or soil trends in seasonal or 1-year intervals, and managers can be alerted to possible deteriorating resource conditions with enough lead time to apply convenient restorative prescriptions where necessary.

Results of the first year of monitoring at CNM indicated that vegetation types and soils are mostly very durable under extant and past conditions of climate, visitor use, and management.

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DERIVING ECOLOGICAL CARRYING CAPACITIES FOR RECREATIONAL  
USE OF WILDERNESS CAMP AREAS - A CASE STUDY AT NELSON LAKE,  
YOSEMITE NATIONAL PARK, U.S.A.

HOLMES, DANIEL O.

Visitor observations and trampling vulnerabilities of plant species are integrated in an eleven step process to derive use limits commensurate with preservation of both the vegetation and the wilderness experience. Two types of use limits are derived: (1) limits based upon campsite size, number of campsites, and campsite occupancy ratings, and (2) limits based upon the plant species' trampling vulnerabilities, and the distribution of plants and visitor use.

Campsites, trails, use zones, and vegetation communities at Nelson Lake (elevation 2940 m or 9630 ft) were mapped. The time spent by overnight visitors in each area was recorded on a minute by minute basis. These camper movements were also correlated with their activity types, time of day, and each visitor's campsite of origin. Camper preferences for specific campsites were noted.

Based upon the mapping, observed visitor occupancy of different areas, their activities, and the species' trampling vulnerabilities, the two limits are calculated and compared. The vegetation damage to be expected with different levels of use is presented.

Extreme differences are noted in the carrying capacities of the different plant species and of the same plant species in different areas around Nelson Lake. The need for continual monitoring of vegetation change in wilderness areas is discussed.

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## WHAT WOULD YOU DO WITH, SAY, SAN MIGUEL ISLAND\*

Kolipinski, Milton C.

San Miguel, one of the eight California Channel Islands, lies less than 100 miles west of urban Los Angeles. The United States Department of the Navy owns the island, and by a special agreement the National Park Service cooperates in managing the island's resources.

This paper summarizes existing knowledge of San Miguel's biological resources, both terrestrial and aquatic. Also, it presents a capsule of the island's important archeological, geological and historical resources. The author recommends management and research programs to protect these resources.

A recent era of resource devastation has passed for San Miguel Island. It was characterized by extensive livestock grazing on the land and wholesale slaughter of marine mammals on and near the shore. In the past few decades much of the island's primitive character has returned.

The principle suggestions to manage the island's resources follow:

1. Restore and perpetuate natural ecosystems and cultural features.
2. Protect native plants and animals, as well as cultural features from further detrimental human activities.
3. Control and, to the extent possible, eliminate non-native plants and animals.

\*The inspiration for this title comes from Ian McHarg's, "What Would You Do With, Say, Staten Island", Natural History, Journal of the Museum of Natural History, Vol. 78, No. 4, April 1969.

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PLANT COMMUNITY RESPONSES TO THE USE OF PRESCRIBED BURNING AS AN ALTERNATIVE TO MOWING IN THE MANAGEMENT OF BIG MEADOWS, SHENANDOAH NATIONAL PARK.

COCKING, W. D., BAXTER, E. E., AND LILLY, S. L.

Big Meadows exists as one of the few remaining open grassland communities in Shenandoah National Park. Extensive pasture and old field succession seral stages characterized the vegetation along Skyline Drive when the park was established in 1935. However, forty years of uninterrupted succession has returned most areas to the young forest stage. This has resulted in the loss of many open communities and potentially threatens the existence within the park of several plant and animal species due to the reduction of habitat diversity. In order to preserve at least one extensive area, park personnel have been mowing the meadowland in front of Byrd Visitor Center in the fall of each year in an attempt to arrest succession. This practice has become increasingly expensive in the last decade and appears to be stabilizing the community at the shrub stage rather than the more desirable grassland mosaic. Two management questions are posed: 1) Could the less expensive prescribed burning be used as a substitute for the mowing without adversely affecting the plant community composition? 2) Could the grassland mosaic be maintained better by the use of fire?

Sixteen experimental plots were selected within the mesic upland meadow. Mowing in the fall of 1974, prescribed burning on April 17, 1975, and seral stage (grassland and shrub) were examined in a replicated 2x2x2 factorial design. Clip sampling with 0.25 m<sup>2</sup> quadrats and cover sampling using 0.5 m<sup>2</sup> quadrats was carried out prior to the experimental burn and at six other times during the 1975 growing season. A maximum 73% reduction of living grassland stage biomass occurred one month following treatment and a maximum 53% reduction in the Rubus-Robinia shrub stage was delayed until two weeks later. Significant repair occurred in both communities. There was less than 15% reduction in each by late August when overall control standing crops were 4,113 g dry wt m<sup>-2</sup> and 8,585 g dry wt m<sup>-2</sup> respectively. Changes in community cover included increaser species (eg. Fragaria, Solidago, Potentilla, and Rubus) and others reduced in importance (eg. Dennstaedtia, Polytrichum, Lycopodium, and Robinia). The degree of change was dependent on both treatment and species composition of the community.

The prescribed burning treatment appears to affect the community in much the same way as the current mowing practice with the ecosystem exhibiting a high degree of repairability. The use of burning alone will arrest succession; however, further study is necessary to determine whether it will stabilize as a grass-shrubland mosaic or as a homogeneous shrubland.

## FIRE ECOLOGY AND MANAGEMENT OF LAVA BEDS NATIONAL MONUMENT

MARTIN, R. E., AND JOHNSON, A. F.\*

Fire was an important part of the ecology of the area now included in Lava Beds National Monument. Overgrazing and fire control have greatly modified the plant communities. The changes in vegetation and plans to move toward the historic vegetation (circa 1873) are reported in this paper.

Lava Beds National Monument was established due to its unique lava beds and caves as well as for being the site of the Modoc Indian War of 1872-73. Army photographs clearly show bunchgrasses to be the dominant vegetation in the northern end of the monument in 1873. Analysis of vegetation in the higher-elevation south end of the monument indicate it was predominantly ponderosa pine (Pinus ponderosa Dougl. ex Loud.) frequently visited by fire. Today, most of the bunchgrasses have been replaced by shrubs and exotics, and many of the ponderosa were lost to the western pine beetle (Dendroctonus brevicomis Lec.) and replaced by mountain mahogany (Cercocarpus ledifolius Nutt.) and bitterbrush (Purshia tridentata (Pursh) DC.).

Prescribed burning studies were begun in 1974 to record the effect of documented fires on the vegetation. The fires were prescribed using the best available knowledge to minimize the undesirable effect on the desired historic vegetation and discriminate against other species. Concurrent studies of the effect of fire on raptors, small mammals, deer, and bobcats are mentioned.

Natural fire intervals are predicted from both tree fire scars and lightning fire starts. Scars from 87 snags indicate fire intervals of 5 to 15 years in the ponderosa pine zone. Using lightning fire data from fire control records and probabilities for spread, wind, and overnight carryover, much of the monument would be burned in each 5-year period. Fire spread predictions were made using typical weather patterns and randomly selecting patterns for temperatures, humidities, and winds. Rothermel's fire spread equations and elliptical model were used. Natural features such as lava flows and collapsed lava tubes were considered in fire spread.

A fire management plan for Lava Beds National Monument is proposed. Considerations in the planning are: objectives of management, vegetation and fuel complexes, and practical considerations of restoring fire to fire-protected areas.

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## SPATIAL AND TEMPORAL DISTRIBUTION OF NATURAL FUELS IN GLACIER PARK

BEVINS, C.D. AND JESKE, B.J.

Quantification of natural fuel distributions is necessary to utilize effectively available fire potential and behavior models and to aid in wilderness fire management decision-making. An analysis of over 400 fuel samples taken in Glacier National Park shows ground fuel loadings and packing ratios to be differentiated into five primary succession-cover type categories, ten temporal classifications, and three vertical fuel-vegetative strata.

Glacier's ground fuels can be categorized by primary succession and the existing vegetative cover type into five major fuel array types: upright forest, krummholz forest, alpine meadows, talus-meadows, and lowland meadows-prairie. Upright forest fuel arrays are further classified by ten twenty-year stand age classes. Fuel array packing ratios were also found to be discrete in their vertical distribution for each fuel category and class. Three vertical fuel-vegetative strata are recognized: the compacted needle-fall and undecomposed organic matter, the stratum of fallen stemwood and branchwood and non-woody vegetation, and an upper layer of the supported, woody-stemmed vegetation. During the sampling and analysis, eight fuel array components were considered: fallen woody stems and branchwood in four diameter size classes, forest floor litter, non-woody vegetation, and the stemwood and foliage components of woody-stemmed vegetation. The horizontal distribution of each of the eight fuel components was also quantified by fuel array category, age class, and vertical stratum.

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## FIRE MODELING FOR NATURAL FUEL SITUATIONS IN GLACIER NATIONAL PARK

BEVINS, COLLIN D.

A fire behavior model developed by the USDA Forest Service has been used since 1972 to estimate fire intensity and spread in the up-slope-upwind direction for horizontally- and vertically-uniform fuel arrays. Adaptations have been made to this model allowing its application to non-uniform wildland fuels and yielding fire behavior estimates about the entire fire perimeter.

Field work in Glacier National Park shows natural fuels to be neither horizontally nor vertically uniform in their distribution as assumed by the original fire model. The fuel does appear to be arranged into three fairly discrete vertical strata that can be considered uniform within themselves. These strata are the compacted litter layer, the layer of fallen branchwood and non-woody vegetation, and the woody-stemmed, supported shrub layer. Each stratum is unique in its fuel array characteristics, and therefore, its burning qualities. The horizontal distribution of each stratum's fuel loading has also been quantified.

The newly-adapted strata fire model accepts as inputs the entire range of fuel loading values for each stratum rather than a single mean value. Fire behavior estimates are made over this horizontal loading distribution for each fuel layer. The stratum of fastest fire spread is selected for each of eight compass azimuths dependent upon the direction and magnitude of the ambient wind and slope. The simulated fire can therefore head, flank, and back through the fastest available fuel layer based upon the layer's natural variability. Estimated behavior variables include rate of perimeter increase, fireline intensity, width, and residence time, flame length, tree crown scorch and ignition temperature heights, and the stratum of fastest fire spread.

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## A CHAPARRAL FIRE PLAN FOR PINNACLES NATIONAL MONUMENT

BISWELL, H.H., AND J.K. AGEE\*

Fire has always been an integral part of California's chaparral, and the vegetation is well adapted to it. Occasional fires in chaparral reduce dead fuels and maintain a vegetation mosaic by encouraging sprouting of some shrubs and germination of others. At Pinnacles National Monument, where the primary vegetation type is chaparral, the historical fire management strategy was total fire suppression. The successful use of this policy has resulted in high volumes of dead fuel and a disappearing vegetation mosaic. Wildfire hazards are extremely high during summer months.

National Park Service fire policy changed in 1968, when prescribed and natural fires, now called management fires, were allowed in certain areas. The chaparral fire management plan for Pinnacles begins with a research plan that has evolved from the park's master plan and natural resources management plan. The three year research plan will experiment with three kinds of burning techniques under varying combinations of weather, fuels, and topography, correlating fire behavior and effects to the indexes of the National Fire-Danger Rating System.

The Pinnacles area has been divided into 14 fire management units, most of which will remain unburned during the research phase. In addition to testing burning techniques, studies will include sampling of the existing vegetation and its condition, fire history, direct impacts of fire on the site, successional patterns of vegetation after burning, and the extent to which fire restores the appearance and character of the original chaparral cover that evolved with recurring fires.

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FIRE-RESILIENT FORESTS OF DOUGLAS FIR IN OLYMPIC NATIONAL PARK: AN  
HYPOTHESIS

FONDA, R. W.

Douglas fir and its associated species form fire-resilient communities, because they can re-establish their niche structure on sites after a destructive fire. The history of fire in the eastern Olympics suggests that at least once every 150-300 years a long period of dry weather coincided with a high fuel supply to support massive and widespread fires. This frequency of fire, combined with the long life span of Douglas fir, has maintained Douglas fir in an area that should otherwise support forests dominated by the climax species western hemlock. The Douglas fir community is not fire-stable, however, because individual organisms cannot survive the environmental perturbation of fire.

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PAST AND PRESENT INFLUENCE OF FIRE IN GUADALUPE MOUNTAINS AND  
CARLSBAD CAVERNS NATIONAL PARKS

AHLSTRAND, G. M.

Fires of natural origin have been and should continue to be an active process within ecosystems of the extreme northern Chihuahuan Desert and adjacent area. Human influence over the past 125 years has greatly modified some of the ecosystems in this semi-arid region. In this paper are discussed some of these modifications and how they have altered the role of fire in what are now Guadalupe and Carlsbad Caverns National Parks. The use of prescribed burns to attain certain resources management objectives is also presented.

Carlsbad Caverns and Guadalupe  
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The Ecological Role of Fire in North Rim Ponderosa Pine Forests,  
Grand Canyon National Park

Peter S. Bennett

The National Park Service has supported a research program since 1970 for the evaluation of ecological effects of fire within North Rim forests of Grand Canyon National Park. This project is broad in scope, dealing with its subject at the ecosystem level.

Research has been conducted on the effects of fire exclusion for long periods of time and also on the effects of prescribed burning. Physical and biological soil properties, vegetational, floral, faunal vertebrate, and fuel loading effects were considered.

Fire exclusion within North Rim Ponderosa forests has been an important factor in shaping these ecosystems for the past 60 years. The principal effects have been floral impoverishment, major shifts in soil microfloral composition and the accumulation of fuels of all size classes.

Prescribed fires burning at energy release rates from 700 to 1000 kg cal/m<sup>2</sup>/min result in dramatic changes in affected forest ecosystems. Tree standing biomass is reduced by 10 to 20 percent, the plant species diversity index increases by 123 to 209 percent, soil respiration rate (decomposers) increases by 62 to 201 percent, and net fuel loadings are reduced by 45 to 75 percent. The effects on the vertebrate fauna are more complex than they are on the vegetation but are also less pronounced.

Palynological and dendrochronological data show that the ponderosa forest, within the Pt. Sublime study area, burned every 27 + 6 years before European settlement. Preliminary data suggest that the mean fire size in these times was 1.6 ha.

Recommendations are made to management for the maintenance of these forests as natural ecosystems.

Grand Canyon National Park  
Grand Canyon, Arizona

## MOOSE-FOREST-FIRE ECOLOGY IN ISLE ROYALE NATIONAL PARK

Janke, R. A.

Research on the ecology of the upland boreal forest type of Isle Royale National Park has been in progress for several years. Thus far, studies of the effects of moose and fire on this ecosystem have been emphasized. A comparison between moose-browsed and un-browsed areas has revealed striking changes in the density, structure, tree species composition and ground cover of the forest since this animal established a population in about 1910.

Extensive man-caused fires during a period of mining activity in the 1800's have also greatly modified the forest. A comparison of the existing forest, as recently sampled, with that of 1847, as determined from analysis of original land survey notes, has indicated that much of Isle Royale's boreal forest is now in relatively early stages of succession as compared with pristine conditions.

Successional trends following fire have been studied by: (1) intensive sampling of selected stands, including determination of tree age structure, in order to reveal changes with time within each stand and (2) by comparison of about 250 forest plots of varying ages with one another. These same plots are currently being used to determine the relationship between tree reproduction and the environmental parameters affected by fire and post-fire succession. Successional trends generally lead toward a more combustible forest. This effect is moderated by moose-browsing.

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## YELLOWSTONE'S NATURAL FIRE PROGRAM

Despain, Donald G.

In 1972, Yellowstone National Park initiated a natural fire program allowing fire to play its role in the environment. Approximately 300,000 acres were designated as natural fire zones wherein lightning caused fires were allowed to burn. Through 1975, a total of 25 fires were not suppressed. Only 4 of these burned more than one acre. The largest was 600 acres.

In 1976, the natural fire zones were expanded to include most of the park (1,700,000 acres). Fires are still suppressed where they could threaten developments and neighboring U. S. Forest Service areas that do not have an approved natural fire management plan. A cooperative agreement with the Bridger-Teton forest permits interagency exchange of fires when mutually agreeable.

By mid-August 1976, eleven more fires were allowed to burn. One reached more than 1,000 acres. There appears to be a logistic distribution of fire size with large fires occurring as rare but persistent phenomena.

Fire, uninfluenced by modern man, is a complex phenomenon with limiting factors and feedback mechanisms.

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## FIRE MANAGEMENT IN EVERGLADES NATIONAL PARK

BANCROFT, WILLIAM L.

Fire is a natural factor in the Everglades. Before the arrival of European man lightning and Indian-caused fires perpetuated a forest of South Florida Slash pine, Pinus elliottii var, densa, and with water maintained the sawgrass prairie. After the arrival of European man the character of the Everglades was altered by drainage and severe fires. A fire management program began in Everglades National Park in 1972 to integrate fire and water management in order to perpetuate pine forests interior sawgrass glades, and coastal prairies.

Fire ecology research was conducted at Everglades National Park from 1953 to 1971 to assess the role of fire in the pine forests and sawgrass glades. These studies indicated that the rockland pine forest and sawgrass glade were sub-climax communities that without fire would be replaced by tropical hardwoods. The fire management program was based on these studies.

Lightning-caused fires, human-caused fires, and prescribed burns are used under a predetermined prescription when they meet approved resource management objectives to perpetuate the fire sub-climax communities. The fire prescription is based on location, drought index, soil moisture, and water level. Fires that do not meet approved resource management objectives are wildfires and suppressed.

Since the program began, 21 wildfires (32,000 hectares), 82 lightning-caused fires (6,000 hectares), 23 human-caused fires (3,000 hectares), and 177 prescribed burns (16,000 hectares) have occurred.

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PATTERNS OF SOIL EROSION AND VEGETATION DAMAGE ASSOCIATED WITH TRAILS  
AND CAMPSITES IN GREAT SMOKY MOUNTAINS NATIONAL PARK

Hickler, Matthew G. and Bratton, Susan Power

The purpose of this study was to quantify physical conditions of backcountry campsites and trails as they now exist in Great Smoky Mountains National Park. Data collection for each trail included a series of measurements for width, depth, slope, aspect, forest type, and degree of erosion. All mud holes and extensively eroded areas were recorded. Data collection for both legal and illegal campsites included the type of site, topographic position, site vegetation, site dimensions (including the size of eroded or damaged areas), the extent of firewood removal, the quality of the water source and a general rating of impact.

The degree and type of trail erosion shows correlations to forest type, topography and the section of the Park where the trail is found. A section of trail in spruce-fir forest, for example, is frequently more eroded than a section of the same trail in an adjoining forest type.

The trampling damage associated with Appalachian Trail shelters is not necessarily greater than that associated with other heavily used campsites. Illegal campsites are usually, but not always, smaller than nearby legal campsites and outnumber the legal campsites by more than 4:1 in some sections of the Park. Again, some sections of the Park have more problems with campsite erosion and illegal camping than other sections.

Both the trail and campsite data are keyed to master maps showing the position of each sampling site. The trail data were processed on an IBM 360 computer and are available on punched cards.

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CULTURAL INFLUENCES ON SUBALPINE AND ALPINE MEADOW VEGETATION IN YOSEMITE NATIONAL PARK, U.S.A.

HOLMES, DANIEL O.

The perceived influences of cultural activities upon meadow areas in national park wilderness strongly affect management policy. Professional, popular, historical, and contemporary concepts of the influences of people's activities on the higher meadows in Yosemite are analyzed.

The origins and ecology of the particular meadows of concern are discussed and the nature of the historical information sources is presented. The human-related activities of burning, hunting, grazing, hiking, and horseback riding are analyzed in terms of the past uses of the meadows for sustenance, commercial gain, and recreation.

It is shown to be unlikely that hunting by Miwok Indians had much influence upon meadow vegetation; the probability of the Miwoks having burned the meadows is also determined to be low. Domestic sheep grazing, which persisted for about 35 years prior to the park's establishment and effective trespassing control, is considered to have probably had no important and lasting ecological effects. The effects of recreational use are found to have been strictly localized. Influences of trail and campsite use upon vegetation in adjacent meadows is emphasized, including the issues of meadow invasion by lodgepole pine (Pinus Murrayana Grev. & Balf.), invasion by alien plant species, and soil erosion.

In conclusion, the cultural activities discussed seem to have had no lasting effects on the meadow vegetation, with the exception of specific locations that have been heavily grazed or trampled by people and livestock.

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MANAGEMENT STUDIES OF HUMAN IMPACT AT BACKCOUNTRY CAMPSITES IN  
OLYMPIC NATIONAL PARK, WASHINGTON, U.S.A.

MOORHEAD, B B., AND SCHREINER, E. S.

Recreational activities such as hiking and backcountry camping have increased more than threefold during the past ten years in Olympic National Park. In this paper we report studies of the biophysical characteristics of backcountry campsites and evident relationships between visitor use, consequent site alteration, and the relative sensitivity of different camping locations and plant communities to trampling impact.

Measurements commonly used in plant synecological studies were adapted to meet the operational constraints of foot travel in remote, rugged terrain and frequent precipitation. New methods for extensive survey of human impact, including the use of radial line intercepts and printed 'key-sort' cards, are described.

Biophysical data were collected from June to September at 73 backcountry camping locations, including 726 individual campsites, between 1973 and 1975. Results indicate that few broad patterns relating trampling severity to specific site factors hold throughout the heterogeneous terrain of this park. A correlation pattern is evident between radial size of trampled bare soil at a site, the percent of coarse rock fraction at the surface, and the percent of forest canopy cover.

Management priorities include the need to limit campfire-building behavior in certain plant communities and the trend of proliferating campfire sites, which evidently create new quasi-destinations for hikers and enlarging social zones of concentrated trampling. Our experience also points up the usefulness of establishing baseline maps of campsite abundance and site alteration due to trampling at key backcountry camping locations to monitor use trends and the effectiveness of protective management actions.

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EFFECTS OF HUMAN TRAMPLING ON SUBALPINE VEGETATION, YOSEMITE NATIONAL PARK, SIERRA NEVADA, U.S.A.

Holmes, Daniel O., and Dobson, Heidi E. M.\*

Human trampling is shown to have detrimental effects upon low-growing vegetation in the wilderness of Yosemite National Park. Measurements of the trampling vulnerabilities and subsequent recoveries of 22, perennial plant species are given.

Natural stands of plants near 2900 m (9500 ft) elevation were trampled experimentally. The trampling effects are evaluated in terms of the percent of original cover surviving 100 "standard steps" on a  $\frac{1}{2}$  m by 1 m area. Trampling impact on plants is viewed as the collective result of several distinct trampling effects: shearing, crushing, gouging, grinding, and ripping.

Herbaceous plants with basal leaves generally exhibited the greatest resistance to trampling. The possession of pliable, and leathery and thick basal leaves was usually essential for a high survival rate. Other factors, such as the size and erectness of the leaves, strength of the petioles and nodes, woodiness of the stems, and the extent of the root system, influenced plant resistance to varying degrees. In the late summer (September), plants were found to usually be more vulnerable to trampling damage than in the early summer (end of July to mid-August). Mixed, layered communities or moist, peaty soil with a dense root content and a stable surface tended to cushion the plants from damage. Plants most sensitive to trampling were those with woody stems above the ground and those with tall, entirely herbaceous, and caulescent shoot stems.

High recovery rates usually occurred when the regenerative buds were at or below the soil surface, or when at the time of trampling, the plant was near the end of its growing season.

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VISITOR IMPACT ON SUBALPINE MEADOW VEGETATION IN GLACIER NATIONAL  
PARK, MONTANA

HARTLEY, ERNEST

This research was conducted to determine some of the qualitative and quantitative relationships between human activities and the stability of subalpine meadow vegetation at Logan Pass in Glacier National Park. Data are presented on plant community composition, species diversity, species cover, flower density, plant height, underground storage carbohydrates, and soil compaction as functions of human trampling intensity.

Visitor effects were studied in experimental plots, along heavily used high mountain trails, and across previously undisturbed vegetation. Single individuals walking through dry meadow vegetation leave imperceptible traces, but a small group walking in single file leaves a path of crushed plants. Such damage is temporary if the action is not repeated. People often do retrace the path and create a permanent addition to the trail system. New paths were created in this way during the study period.

Non-structural carbohydrate reserves in the roots and underground storage organs of Erythronium grandiflorum were analyzed to find a possible explanation for the smaller plants, decreased flower production, and lower species cover observed in trampled sites. These characteristics were associated with significant reductions in carbohydrate content.

The attrition of trampling-sensitive plants accounts for floristic changes in trampled communities; plants of Phyllodoce empetrifolia, Senecio resedifolius, and Polytrichum alpinum rapidly disappeared in trampled plots and did not return after six years. Certain trampling-resistant species such as Carex nigricans invade disturbed sites if trampling is not too severe.

People are an unnatural part of high mountain ecosystems. It is principally in relationship to man that alpine plants are considered fragile.

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## VISITOR USE IMPACT IN SUBALPINE MEADOWS

LEMONS, J. D.

Vegetative stands with different levels of human use but within the same subalpine meadow community were studied to determine whether a correlation exists between vegetative condition and consequences of trail use (soil compaction).

Regressions of the species attributes frequency, density, and importance values (I.V.) respectively, for each of the 20 most common species on soil compaction were made for each stand. Carex exserta was the only species to increase in attribute value as soil compaction increased, thereby indicating resistance to human use impacts. The regression of species attributes for C. exserta on soil compaction was statistically significant, thereby indicating that this species could serve as a quantitative indicator species for visitor use effects. The remaining species decreased in stand attribute values as stand soil compaction increased. Thus, most species were sensitive to human use effects. However, the decrease was not systematic for any of the decreaser species and therefore they could not be used as indicator species.

A measure of similarity of disturbed stands to an undisturbed reference stand was determined by calculating coefficient of community values (CC), using the respective attributes described above. The CC values for all stands were significantly correlated with soil compaction.

Since individual species response to human use may be complex within the context of community change, CC values may be of greater value for predicting response to human use. Because soil compaction measurements are easily acquired and are a function of human use within an area, the correlation of soil compaction with CC values along an undisturbed to disturbed gradient may aid national park managers in predicting vegetative response as a function of human use.

National Park Service  
Yosemite National Park  
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GEOLOGY, SOILS, AND RECREATIONAL LIMITATIONS OF BEAR ISLAND, WISCONSIN, APOSTLE ISLANDS NATIONAL LAKESHORE

Kowalski, W.L.

A Quaternary geologic history of Bear Island is formulated with emphasis from the most recent glaciation (Valders Stade of Late Wisconsin glaciation) through the ensuing postglacial lake stages to the present. Abandoned shorelines from past levels of postglacial Lake Superior are evident. These shorelines correlate with glacial lake stages of the Post-Duluth series which occupied the Lake Superior basin approximately 10,000 years ago. Maps depicting abandoned shorelines and depth to bedrock are presented.

Soil materials on Bear Island exhibit evidence of being water laid deposits. Soil borings reveal these materials to be variable in depth, 0 to 5 feet or more over sandstone bedrock. Soils vary in texture from sand through clay and in drainage from poorly drained to well drained. A Bear Island soils map is presented. Soils are rated as to the limitations they pose for specific recreational uses (i.e. paths and trails, camp sites and picnic areas, and septic tank disposal fields) and presented on color-coded soil limitation maps. By interpreting these maps, park planners will be able to locate potential sites for public enjoyment in areas that will best tolerate human impact.

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IMPACT OF CHLORINE POLLUTION IN THE UPPER POTOMAC AND ANACOSTIA ESTUARIES. Wester, Horace V. and Rawles, Steven D.<sup>1</sup>

There is ample documentation that during the first part of this century the upper Potomac and Anacostia estuaries, which flow through Washington, D.C. were very healthy ecosystems. Since that time the authors and others have noted marked decline to elimination of much of this life. This diminishing diversity and density of flora and fauna in these upper tidal estuaries indicates that a major ecological disruption to this ecosystem has occurred.

Field observations, plot studies and data from controlled environment investigations with Cabomba caroliniana, Elodea canadensis, Potamogetan crispus, P. pectinata, and Vallisneria spiralis indicate that chlorine pollution may be a significant cause of this critical environmental problem affecting these once locally prevalent plants. In bioassay tanks, these plants showed marked retardation of growth, loss of chlorophyll, and even collapse when total available chlorine levels in the estuary water source occurred in a range of .05-.125ppm under low turbidity conditions.

Environmental factors which appear to be correlated to this ecosystem problem are as follows:

1. Concentration of chlorine pollution sources from sewage treatment facilities and power plants, in the affected estuaries.
2. Tidal action which, in effect, creates a semi-enclosed system. This increases the ecosystem's vulnerability to this pollution problem.
3. Light penetration as enhancing assimilation and sensitivity of submerged vegetation to chlorine toxicity.

Since this representative ecosystem is part of the Chesapeake Bay estuary which supports an annual 41 million dollar fish and shellfish industry, in addition to sport fishing and hunting, etc., it is important that we get a better understanding of the problem scope.

Further investigation using bioassay tanks are being conducted to further substantiate the specific role of environmental factors which affect the Potomac River basin and ultimately, the Chesapeake Bay estuary.

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THE DECLINE OF DESERT HOLLY AS RELATED TO OZONE POLLUTION IN  
DEATH VALLEY NATIONAL MONUMENT

Jack Fisher

Desert Holly (*Atriplex hymenelytra*) was grown in a filtered air greenhouse in Riverside at the University of California, and fumigated with the same levels of ozone which occur in Death Valley during summer months. The levels of .15 to .18 ppm ozone were used. Photosynthesis was reduced in exposed leaves of Desert Holly. Water use efficiency was reduced because of ozone induced stomatal closure and increased mesophyll resistance. The reductions were most pronounced in plants which were under high water stress. Three controlled levels of water stress were utilized for experimental and for control plants. From the results I conclude that abnormally high ozone concentrations found in Death Valley during the summer months could be a major factor in the decline of the Desert Holly community. The damage from ozone is more pronounced when plants are under high water stress. Ozone is present in Death Valley in higher concentrations during the summer months when plants are under water stress; thus the degree of damage caused by ozone is maximized.

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THE IMPACT OF EXOTIC PLANTS ON THE NATIVE VEGETATION OF  
THEODORE ROOSEVELT ISLAND. Thomas, L. Kay, Jr.

Three exotic plant species were studied. Lonicera japonica, Thunb. (Japanese honeysuckle) and Hedera helix, L. (English ivy) are destroying the forests (except the swamp) of this low lying island in Washington, D.C. The marsh on this Potomac River island is being changed by Iris pseudacorus, L. (European yellow iris). Besides studying impact, limiting factors were also determined.

On the island upland L. japonica growth increases with light intensity. When shade is not a factor that limits this evergreen vine, it overwhelms and kills small trees and shrubs, and it inhibits reproduction, especially of the following trees which are among the overstory dominants on the upland of the island: Ulmus americana, L., Prunus serotina, Ehrh., and Liriodendron tulipifera, L.

On the upland there is no other factor that is stronger than light for limiting H. helix growth, but it is not as strong a limiting factor for this species as it is for Lonicera. On the flood plains growth and distribution are limited by water table height. In both habitats Hedera suppresses the growth of native herbs. This evergreen tendril liana climbs overstory and understory trees as well as small trees and is able to shade and kill them.

Marsh that would otherwise be occupied by Peltandra virginica, (L.) Schott & Endl. are taken over by I. pseudacorus. In the swamp-marsh transition Acorus calamus, L. takes over Iris areas. The lengths of time Iris is inundated by water comes closest to a factor limiting its growth. The shorter the inundation, the greater is the growth rate.

U.S. Department of Interior, National Park Service,  
National Capital Parks, Ecological Services Laboratory,  
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THE STATUS OF FIVE WOODY EXOTIC PLANTS IN THE TENNESSEE DISTRICT OF  
GREAT SMOKY MOUNTAINS NATIONAL PARK

Baron, Jill

A study was made of the status of five exotic woody plants (*Albizza julibrissin*, *Lonicera japonica*, *Ailanthus altissima*, *Pueraria thunbergiana*, and *Paulownia tomentosa*) on the Tennessee side of the Great Smoky Mountains National Park. Two hundred and seventy miles of roads and trails, as well as streamsides and old homesites were surveyed. *Pueraria thunbergiana* was not found in the survey area. From the occurrences of the other four species the following generalizations were made: these exotics appear to be confined to a low elevation (below 3400ft.) successional forest dominated by *Liriodendron tulipifera*; the species are most often found along roads or around buildings where man has disturbed the natural environment; there is little or no invasion of virgin forest; the populations are probably stable or decreasing in size.

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**IMPACTS ON NATIONAL RECREATION RESOURCES OF CONSTRUCTION  
AND OPERATION OF A KAIPAROWITS POWER PLANT**

**GIAMBERDINE, RICHARD V.; CARTER, ALEX R., JR.; FARIS, DOUGLAS  
D.; AUSTIN, JOHN T.; KUSSMAN, JOEL V.**

This study was undertaken to assess the impacts on national recreation resources that would result from building and operating a 3,000-megawatt, coal-fired power generating plant near the Kaiparowits plateau in southern Utah to supply electrical power to Arizona and southern California.

Utilizing existing data and current methodology, the report analyzes impacts on air quality, fish and wildlife, scenic views, visitors, tourism, and other recreational values associated with the five national parks, four national monuments, and one national recreation area surrounding the two possible plant sites.

The results of the analysis indicate that there would be significant deterioration of air quality in Bryce Canyon, Grand Canyon, and Capitol Reef National Parks, and in Glen Canyon National Recreation Area. Also, there could be mercury contamination of Lake Powell, degradation of regional aesthetic quality and scenic views, and a loss of recreation-use days and tourist-related expenditures.

The study pointed out that more sophisticated theoretical estimations (modeling) for air quality analyses are imperative to assure uniform and accurate predictions. Similarly, it was apparent that the methods utilized to evaluate the effect of the power plant and its plume on the aesthetic resources of the region need to be refined if the magnitude of such impacts is to be represented accurately, consistently, and meaningfully.

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THE HOLE IN THE SYSTEM: A GREAT PLAINS NATIONAL PARK

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NO ABSTRACT SUBMITTED

## ORNITHOLOGY IN THE NATIONAL PARKS

Robertson, W. B., Jr.

The National Parks have provided a reasonably active theater for research in ornithology, but the ornithological research possibilities of National Park System areas, particularly for bird study that extends beyond basic faunistics, have been very imperfectly exploited. This paper surveys the current state of ornithological knowledge of National Park System areas. The approach is primarily historical within the major sectors of ornithology with more detailed reference by way of example to various work completed and in progress. We also indicate research facilities in NPS areas of specific interest to ornithologists and suggest some research problems that seem to have interesting potential. Closing comments undertake (perhaps rashly) to propose modest attitudinal adjustments on the part of the National Park Service and by ornithologists of the scientific community that may advance ornithological research in the National Parks.

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ECOLOGY OF A THERMAL SPRING ALGAL-FLY COMMUNITY

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NO ABSTRACT SUBMITTED

## SMALL MAMMAL POPULATIONS IN NORTHERN DEATH VALLEY NATIONAL MONUMENT

O'Farrell, T. P. and O'Farrell, J. T.

The major objective of this study was to investigate the population dynamics of small mammals inhabiting the *Larrea/Ambrosia* vegetation association in the northern portion of Death Valley National Monument, and to compare the results with population parameters established for similar species in the shrub-steppe of the northern Great Basin Desert.

Small mammals were live-trapped at frequent intervals to establish species composition, relative abundance, biomass, home ranges, and reproductive performance. These measurements were examined in relation to abiotic variables, such as soil and air temperatures and precipitation, as well as to production of food and overwintering population densities.

During 1975-1976, over 6,000 trap-nights of effort were expended during 18 trapping sessions. Over 350 individual mice representing seven species were captured more than 2,500 times. The long-tailed pocket mouse, *Perognathus formosus*, was the most numerous species trapped and appeared to completely dominate the study area in terms of both numbers and biomass. The annual cycles of emergence from winter torpor, density, reproductive activity, growth, home range sizes and duration of activity on the surface were quantified. Preliminary analyses indicated significant differences between characteristics of this population and those of *Perognathus parvus* in northern shrub-steppe.

One of the most striking adjustments in population dynamics were prompt changes in reproductive performance correlated at least in part with changes in food supplies. There was little food production during 1974-1975 in the Grapevine area, and no reproduction was observed in *Perognathus formosus*. Late, heavy rains in 1976 stimulated germination of winter annuals, and the pocket mice responded by breeding within two months. *Perognathus parvus* always bred, albeit at low rates, even in years of extreme drought and poor food production.

We concluded that populations of small mammals in Death Valley were responding to a matrix of environmental stimuli, but the most important cues were probably soil temperatures, availability of food (seeds), and the overwintering density of the most numerous species.

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ENVIRONMENTAL VARIABLES AND MULTIANNUAL CYCLES IN POPULATION DYNAMICS OF THE MONTANE VOLE, MICROTUS MONTANUS, IN GRAND TETON NATIONAL PARK.

PINTER, AELITA J.

Multiannual fluctuations in population density of small rodents have been recognized since antiquity. These fluctuations occur with sufficient regularity to be commonly designated as "cycles."

The present report documents a seven year study of such a cycle in the montane vole, Microtus montanus, in Grand Teton National Park. It will be demonstrated that environmental variables, acting through the reproductive responses of Microtus, are among the most significant factors determining the length as well as the amplitude of a given cycle. The mechanisms whereby environmental variables exert physiological effects on Microtus will also be discussed.

In view of the fact that Microtus is one of the principal prey species for a large number of predators in Grand Teton National Park, the cyclic abundance and scarcity of these rodents is of paramount importance in regulating the numbers as well as the distribution of some predators on a seasonal as well as on a multiannual basis within the Park. Data will be presented to support this contention.

The financial support of the New York Zoological Society as well as the availability of the facilities of the Jackson Hole Biological Research Station is hereby gratefully acknowledged.

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EFFECTS OF PRESCRIBED BURNING ON SMALL-MAMMAL COMMUNITIES IN LAVA BEDS  
NATIONAL MONUMENT, CALIFORNIA

FRENZEL, R. W., STARKEY, E. E., AND BLACK, H. C.

Small mammal communities are a significant part of the Lava Beds ecosystem. Small mammals are important prey species for many avian and mammalian predators in the area and are potential vectors of parasites and diseases. They may also have a significant influence on natural succession after a fire. This paper studies the effects of two prescribed burns on the population levels and species composition of small mammals.

An area of about 300 acres of rangeland was burned in June 1976 to reduce densities of western juniper, antelope bitterbrush, mountain mahogany and sagebrush. Another area of about 400 acres of cheatgrass was also burned in June, 1976 in an attempt to favor native bunchgrasses and decrease the abundance of cheatgrass, an exotic.

Small mammal populations were sampled on these burns and on control areas. Mark-recapture trapping began in April, two months before burning, and continued through September at 30 day intervals. Length of individual trapping periods was three days, and total trapping effort equalled 7200 trap nights. This sampling schedule has allowed the determination of the immediate effects of the fires on the small mammal communities.

Removal trapping was also used to sample the populations prior to burning. All small mammals captured during a 15 day period (15,000 trap nights) were removed. This procedure will be repeated during the spring of 1977, thus allowing comparisons of relative abundance, species composition, fertility factors, body weight and a variety of other parameters between populations present before burning and one-year later.

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THE EFFECT OF CAMPGROUNDS ON SMALL MAMMALS IN  
CANYONLANDS AND ARCHES NATIONAL PARKS, UTAH

CLEVENGER, G. A. AND WORKMAN, G. W.

Campground use in our national parks is increasing yearly, but little quantitative data is available concerning the impact this use is having on the ecosystem of the campground and surrounding area. This paper reports on the effects of campgrounds on small mammal populations in Arches and Canyonlands National Parks, Utah.

Data collection consisted of live-trapping from April to November, 1975 (12,336 trap-nights). The populations of ords kangaroo rat (Dipodomys ordii), antelope ground squirrels (Ammospermophilus leucurus), deer mice (Peromyscus spp.), woodrats (Neotoma spp.), Colorado chipmunks (Eutamias quadrivittatus), and desert cottontails (Sylvilagus audubonii) inhabiting campgrounds were compared with a non-campground control area.

Squaw Flat campground in Canyonlands National Park contained significantly higher populations of woodrats and Colorado chipmunks. Devil's Garden campground in Arches National Park exhibited significantly higher populations of Colorado chipmunks and deer mice. No significant difference was found between campground and control areas for all other species. Species occurrence for campgrounds and control areas was identical.

Results indicate that campgrounds may have any effect on the small mammal populations of an area, and this should be taken into consideration when formulating management plans for national parks.

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NATURAL HISTORY OF THE KAIBAB SQUIRREL IN GRAND CANYON  
NATIONAL PARK

HALL, J. G.

The Kaibab squirrel is a form of the tassel-eared squirrel and occurs only in the forests of the Kaibab Plateau just north of the Grand Canyon. This study has focused mainly on food habits and attempts to use this information to monitor population levels.

Because of its remarkable dependence on a single plant species, the ponderosa pine, the Kaibab squirrel is essentially restricted to pure stands, approximately 90% of which lie in Kaibab National Forest, 10% in Grand Canyon National Park. Squirrels feed heavily on pine seed during favorable years and also consume buds, staminate cones and phloem of sub-terminal twigs which are available annually. There is a very marked preference for certain individual trees.

Since these animals are extremely shy, a method of attempting to census them indirectly by tallying the peeled sub-terminal twigs on circular, tenth-acre plots has been used in recent years. Results of these tallies show a down-trend in the population, particularly alarming in the National Park. Several possible explanations will be discussed.

Summer home ranges and activity patterns were studied on a small scale by radio-tracking and visual-tracking of marked animals. Minimum size of home range is typically 10 to 15 acres but may be as large as 30 acres. Two distinct activity peaks occur each day, a major one in early morning, a minor one in late afternoon. Squirrels rest mostly in trees but may cover 2 miles on the ground in a day.

Future research needs are: calibrating the census technique, studying effects of fire-suppression and obtaining data on reproductive performance.

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POPULATION ORGANIZATION AND REGULATORY MECHANISMS OF PINE MARTENS IN  
GRAND TETON NATIONAL PARK, WYOMING

CLARK, T. W. AND CAMPBELL, T. M.

Pine martens (Martes americana) are a relatively common resident, but rarely seen predator of coniferous forest ecosystems in certain areas. Historic overexploitation as a fur resource eliminated or reduced populations and ranges and their present status is largely unknown. Many basic questions concerning population organizational systems and regulatory mechanisms characterizing unexploited martens remains unanswered. Grand Teton National Park offers an area protected for over 25 years and abundant martens. Progress based on the first 14 months of a long-term field study aimed at determining the role which animal behavior and environmental factors play in regulating marten populations and social organization will be given.

Population structure and dynamics are being determined from live trapping. Twenty martens (11 M:9 F) have been captured 234 times in the 4.5 square mile study area. In spring-summer, 1975, spatially males utilized exclusive areas; subsequently they have overlapped considerably. Females consistently overlap each other and males. Home range sizes averaged 600 acres for males and 220 acres for females.

Food as a regulatory is being investigated via scat analysis and monitoring the rodent prey base. A phytosociological analysis of habitat structure correlated with locations of relative capture success will indicate high use areas. Behavior is indirectly being investigated from trapping (e.g., shared capture sites).

Grand Teton National Park is serving as a control for a nearby site on Teton National Forest currently being logged; logging effects on martens are being determined. The above methods are being employed and also radio telemetry tracking.

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## MAMMALS OF GUADALUPE MOUNTAINS NATIONAL PARK

CORNELY, JOHN E.,\* GENOWAYS, HUGH H. AND BAKER, ROBERT J.

Zoogeographically, the Guadalupe Mountains are an island inhabited by animals of Rocky Mountain affinities surrounded by Chihuahuan desert. The complex interactions of many environmental factors, including a wide variation of elevations, a variety of soil types, and the rugged dissected topography of the mountains, have resulted in a unique and diverse community of plants and animals. The mammals of Guadalupe Mountains National Park are a unique mixture of desert, grassland, riparian woodland, montane, and widespread species.

Fifty-four species of mammals are known to occur in Guadalupe Mountains National Park. An additional nine species may occur in the park. Eight species that once occurred in the area are no longer present. These include the black-tailed prairie dog, bighorn sheep, bison, pronghorn, white-tailed deer, gray wolf, grizzly bear, and the extinct Merriam's elk. In 1928, 44 Rocky Mountain elk were released in McKittrick Canyon. Very little data exist on this introduced herd, but approximately 150 elk now occur in the park.

Small mammals of special interest include a rare subspecies of eastern cottontail, Texas antelope squirrel, gray-footed chipmunk, Guadalupe Mountains pocket gopher, and Guadalupe Mountains vole. The ranges of these mammals are limited to the Guadalupe Mountains and neighboring mountain ranges.

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RHYOLITE RADIONUCLIDE UPTAKE BY SELECTED PLANT SPECIES AND POCKET  
GOPHERS IN YELLOWSTONE NATIONAL PARK

DIEM, KENNETH L. AND KENNINGTON, GARTH S.

During a 1961-63 comparative study of the influences of 5 different Yellowstone National Park rock substrates on northern pocket gophers, 1.5-month, replicated exposures of incisors and femurs of 29 specimens to X-ray film revealed high radionuclide concentrations in the bone tissues of the Pitchstone Plateau rhyolite area specimens. Eight-month exposures of Pitchstone gopher food plants, i.e., Agoseris, Achillea and Aster revealed equally high radionuclide concentrations. Morphological anomalies were not observed in the Pitchstone gopher specimens. However, the average annual population of pocket gophers/ha on the Pitchstone Plateau was only 20% as large as those on the other 4 substrate areas. Autoradiographs of the bones and teeth of 123 pocket gophers from the 4 nearby substrate areas revealed low radionuclide concentration. A variety of alpha and beta analysis techniques failed to adequately identify or quantify the specific radionuclide concentrations. In 1974, an alpha-beta analysis of warm water flowing from an Idaho formation, comparable to the Pitchstone Plateau, revealed a concentration of 88 pc/l of Ra-226 and small concentrations of U-234, -235 and -238 and Th-230 and -232. This circumstantial evidence indicates a need for a thorough radionuclide analysis of the water, plants and animals associated with the rhyolite flows extending over 6500 km<sup>2</sup> in Yellowstone National Park and surrounding states.

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ECOLOGIC STUDIES OF COLORADO TICK FEVER IN THE ROCKY MOUNTAIN  
NATIONAL PARK

McLEAN, R. G., FRANCY, D. B., BOWEN, G. S., EADS, R. B.,  
SHRINER, R. B. AND TRIMBLE, J. M.

In depth studies of Colorado Tick Fever (CTF) within natural foci in the Rocky Mountain National Park (RMNP) of Colorado were conducted in 1974-75. Approximately 6000 mammals of 26 species were trapped, measured, examined for ectoparasites, bled, marked and released at various locations throughout the eastern slope of the RMNP. There were 181 isolations of CTF virus from blood clots of small mammals. The predominant species captured and infected with CTF were Eutamias minimus, Spermophilus lateralis, Spermophilus richardsonii, and Peromyscus maniculatus. No virus isolations were made from rodents collected above 9,500 feet in elevation and the habitat type with the highest level of CTF activity was the rocky, south-facing slopes at 8000-9000 feet with open stands of ponderosa pine (Pinus ponderosa), sagebrush (Artemisia tridentata) and bitterbrush (Purshia tridentata). Seasonal differences in CTF isolations from mammals were noted between 1974 and 1975.

Approximately 30 percent of adult Dermacentor andersoni ticks collected from the ground at the various locations were positive for CTF virus with the highest prevalence of infection in the Moraine Park Campground. Peak collections of adult ticks occurred in mid-May and declined sharply by mid-June. Ticks removed from small mammals were primarily immature stages of D. andersoni. S. lateralis had the highest prevalence of infestation with ticks and the highest mean number of ticks per animal. E. minimus was next in both categories. Estimated CTF infection rates of D. andersoni ticks ranged from 4 per 1000 larvae taken from P. maniculatus to 195 per 1000 nymphs from E. minimus.

Population data on rodent species from two separate sites are related to CTF virus activity and the relationship of infection rates in rodents and ticks is discussed.

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RABBITS AND OTHER MAMMALS OF SAN JUAN ISLAND NATIONAL HISTORICAL PARK

WEISBROD, A. R., STEVENS, W. F., AND NORDQUIST, G. E.

The European rabbit Oryctolagus cuniculus was introduced on San Juan Island Washington in the 1880's, then spreading throughout the island, reaching densities as high as 200 individuals per hectare in some years. The intent of this investigation was to describe the basic life history and biology of the rabbit on the island and to explore its relations with other mammal species.

Only twenty species of mammals are recorded for San Juan Island, illustrating the tendency for islands to have fewer species than nearby mainlands. The impoverished faunal assemblage on San Juan Island and the Park probably reflect the Island's unique environment, its isolation following the Pleistocene, and the recent influence of the now dominant mammal, the European rabbit. On San Juan Island the reduced species richness is maintained by the abundance and ubiquitous distribution of the rabbit. Attempts to control the number of rabbits on the Island may result in greater management problems by disrupting a now stabilized biotic community in which the rabbit plays an important role as prey and competitor.

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DISTRIBUTION AND RICHNESS OF MAMMAL SPECIES IN MT. RAINIER NATIONAL PARK

WEISBROD, A. R. AND DRAGAVON, J. A.

Contemporary theories suggest that species distribution and richness are related to the isolation and size of an area. Furthermore, the number of species at equilibrium is a function of population turnover rates. The intent of this study was to determine these parameters as they influence mammal populations in Mt. Rainier National Park, assessing the probable impacts of insularity on mammal distribution and diversity within the Park.

Mammal populations were sampled in 1974 and 1975, correlating species occurrence with certain physical and biotic factors in each habitat. Study areas were established and sampled at three elevations in each of the Park's four major drainages. Four additional sites were located in the adjacent national forest lands and selected for comparability to the park sites. Vegetative components of each study site were determined and compared with concomitant mammal populations along altitudinal gradients, thereby permitting precise delineation of mammal distributions on the mountain.

Over 900 specimens representing 36 species were obtained in approximately 18,000 trap nights in the two-year period. All specimens were identified, sexed, aged, and standard measurements obtained. Stomach contents and reproductive tracts have been preserved and await further analysis. Correlations with physical and biological factors are reported. Estimates of mammal turnover rates are made for the Park. Predictions based on these observations can form the basis of management decisions consistent with overall national park policies.

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MAN-CAUSED MORTALITIES OF COYOTES RADIO-MARKED IN GRAND TETON  
NATIONAL PARK<sup>1</sup>

TZILKOWSKI, WALTER M.\* and KNOWLTON, FREDERICK F.\*\*

Coyote (Canis latrans) mortality was documented in Grand Teton National Park, an environment assumed to be minimally influenced by man. The valley floor of Grand Teton National Park is approximately 256 square kilometers, including 24 square kilometers of non-federal inholdings. Fifty-two coyotes, 26 males and 26 females, all approximately four months of age or older, were collared with radiotelemetric transmitters. The multiple-use transmitters revealed geographic location of the coyotes and served as mortality indicators. Thirty-seven percent (19 of 52) of the collared coyotes were recovered dead. Man was responsible for ninety percent (17 of 19) of these deaths: 13 coyotes were gunshot, one was clubbed, one was trapped, and two were roadkills. Forty-two percent (7 of 17) of the man-caused mortalities were recovered within Park boundaries. Five of these coyotes were killed by gunshot (three in the Park and two on non-federal inholdings) and two coyotes were roadkills. Fifty-three percent (10 of 19) of the coyotes collared in the fall of 1974 were found dead in the period September 26, 1974 to May 25, 1975 as compared to eight percent (1 of 12) of the coyotes collared in the fall of 1975 found dead from September 26, 1975 to May 25, 1976. Man was the principal mortality agent, both within and outside Park boundaries, with the intensity of mortality differing between years.

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<sup>1</sup>Research funded by the U.S. Fish and Wildlife Service Contract # 14-16-0008-1120.

## HUMAN DISTURBANCE AT WOLF DENS--A MANAGEMENT PROBLEM

CHAPMAN, R. C.

Field observations of undisturbed and experimentally disturbed wolf (Canis lupus) dens in Alaskan tundra situations were combined with an extensive survey of available information to derive guidelines for protecting active dens from human disturbance.

Extended observation of denning wolves made in Mount McKinley National Park and in the Brooks Range during 3 seasons, well-documented field simulations of disturbance by campers, an analysis of den site characteristics, a review of published material on the sensory capacities of wolves and their reported reactions to disturbance, as well as a questionnaire survey of land managers responsible for wolves have formed the basis for recommending a size for closed areas around active dens. Closures at pupping dens from initial activity with a minimum radius of 2.4 km (1.5 mi) and extended until at least 1 August are recommended. Protection of auxilliary dens and rendezvous sites without closing very large areas may be difficult due to problems of locating such areas and their impermanence.

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*THE ROLE OF WOLF PREDATION IN A MOOSE POPULATION DECLINE*

*PETERSON, R. O.*

*In the early 1970s many moose populations in Canada and Alaska declined. Causes included extreme winter weather, habitat changes, wolf predation, and liberal hunting regulations. The first two factors were also operative in Isle Royale National Park, and led to increased moose vulnerability to wolf predation.*

*Post-fire forests which supported moose through the 1950s grew out of reach and were little-used in the 1960s and 1970s. Moose shifted to coniferous stands where winter food supply was limited, and the population entered a series of severe winters between 1969 and 1972 at a peak level. In the early 1970s winter malnutrition among moose increased, calf production declined, and newborn calves were physically small. Deep snow increased calf vulnerability to wolves, and predation on young adult moose increased suddenly as cohorts of small calves matured.*

*Wolves exhibited an immediate functional response to high moose vulnerability, evidenced by increased kill rates. A long-term numerical response followed as a second, then a third, large pack became established. The wolf population increased from its lowest point (17) in 1969 to an all-time high (44) in 1976. During the same period the moose population may have decreased by 40% and the wolf:moose ratio altered from 1:80 to 1:20. Although winter severity has moderated and predation on young adult moose has ceased, calf production and survival have remained low.*

*Although the direct cause of most moose mortality has been wolf predation, the underlying reasons for the declining moose population and the increased wolf population were changes in habitat and moose food supply. Wolf predation has continued to be selective; young adults killed by wolves were probably vulnerable because of pre-natal malnutrition, evidenced by small size at birth.*

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## SUMMER SCAVENGING ACTIVITY IN NORTHEASTERN ALASKA

MAGOUN, A. J.

The scavenging behavior of birds and mammals on the North Slope of the eastern Brooks Range was investigated during the summers of 1972 and 1973. Long-term observations were analyzed by 5-minute time periods with respect to scavenger activity and interaction.

Grizzly bears (*Ursus arctos horribilis* Rausch), wolves (*Canis lupus tundrarum* Miller), and ravens (*Corvus corax* Linnaeus) each scavenged at over 50 percent of 15 large mammal carcasses. The major activities of feeding, moving, and resting were accompanied by minor activities such as caching, scraping, and inter- and intraspecific interactions. Behavior at the carcasses varied considerably, being influenced particularly by the dominance hierarchy of the scavengers present. The raven appeared to rely on scavenging more than the other species. Once a large mammal carcass was found by wolves or bears, it was disposed of within 2 to 10 days; avian scavengers required more than 10 days. The remains of a carcass may indicate which scavengers had visited the carcass.

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RELATIONSHIPS OF MOOSE, SODIUM, AND AQUATIC VEGETATION  
ON ISLE ROYALE NATIONAL PARK, LAKE SUPERIOR

AHO, R.W., AND JORDAN, P.A.

The primary source of sodium, whose availability may control the Isle Royale moose (Alces alces) population, is apparently aquatic vegetation. In this paper we report studies of aquatic production and utilization, and seasonal/phenological fluctuations in the sodium content of aquatic vegetation.

An intensive study of aquatic production and moose utilization incorporates eight aquatic moose exclosures constructed in 1975. Preliminary analysis of 1975 vegetation clipping indicates that moose consumed 48.7% of the available  $52.8 \text{ g/m}^2$  (oven-dry weight) of Nitella, the predominant macrophyte in Grace Creek, which averaged 2840 ppm sodium (oven-dry weight). Consumption of aquatics is also being quantified by timed, manual simulation of aquatic feeding.

From aerial photographs taken in July 1975, aquatic habitats have been assigned to one of six categories, mapped, and their areas calculated. The vegetation of a sub-sample of these is being quantitatively sampled in summer 1976, and these standing crop/sodium content data will be extrapolated in order to estimate the total availability of this important nutritional component.

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# STREAM FLOW AFFECTS ON BEAVER POPULATIONS IN GRAND TETON NATIONAL PARK

COLLINS, THOMAS C.

Beaver populations in Grand Teton National Park were studied for four years to assess the influence of stream flow on population abundance, distribution, and movements. This paper reports data which document seasonal movements of the populations in response to changes in stream flow. The results suggest that availability of winter dwelling sites is an important factor limiting beaver density.

The Snake River in GTNP is regulated by the Jackson Lake Dam, while flows of the Buffalo Fork River and Pacific Creek are unimpaired. Low flow rates on the Snake River occur eight to ten weeks later than on the other streams, leaving a critically short period before winter.

Delineation of territory boundaries and observations of ear-tagged beavers facilitated close scrutiny of colony movements. Rates of abandonment and subsequent movement to new denning sites due to seasonal high and low stream flows are similar on all three streams. Reduction of habitat and scarcity of denning sites at low flow rates greatly restrict potential colony density. Most colonies are forced to occupy only larger channels; other colonies abandon areas, as a result of which territorial integrity of existing colonies on the major channels is maintained. Winter populations on each of the streams appear to be at or near carrying capacity.

In conclusion, seasonal movements caused by fluctuations in stream flow are typical of beaver populations in GTNP. Colony density is limited by availability of winter dwelling sites.

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## ECOLOGICAL STUDIES OF BEAVERS IN ISLE ROYALE NATIONAL PARK

SHELTON, P. C.

This summarizes beaver studies conducted on Isle Royale since 1960 as part of long-term investigations of the island's major mammals. During this period the population recovered from a major die-off, probably caused by tularemia, which occurred during the 1950's. Live-trapping and aerial surveys in 1962 indicated a population of about 900 beavers. Wolves then numbered 20 to 25 animals and beaver remains occurred in 11 percent of wolf scats examined. By 1974 beavers had increased to about 2000 animals. Rolf O. Peterson's wolf studies indicated that these animals had increased to over 40 by 1975 and increased occurrence of beaver remains in wolf scats indicated that beavers contributed significantly to the wolf increase. Beavers fed primarily on aspen and birch stands dating from fires which occurred in the late 19th century and in 1936. As stands near water were depleted the rate of cutting decreased while the degree of utilization of cut trees increased. Moose browsing and shade intolerance of aspen and birch reproduction have prevented significant regeneration of beaver foods.

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## MODELS OF TOP CARNIVORE POPULATIONS UNDER HUMAN IMPACT

Gehlbach, F.R., Hudson, J.W., and Rolf, H.L.

Linear algebraic models (with matrix, eigenvalue= 1 for stability) of grizzly bear, cougar, and jaguar populations show that present human impact can be too severe for conservation of these K-selected predators. Models use known or estimated life history parameters and habitat stability or decline. Some results with habitat stability, as in national parks, follow.

Grizzly bears cannot stand more than a 8.5% annual harvest, the two cats no more than 14.3%, if natural mortality is 25% in the first year and 5% thereafter (including an increment to senility). Yet we are aware of annual overkills approximating 39% in Yellowstone grizzlies, 29% in New Mexico cougars, and 36% in Mexican jaguars.

If about 1000 jaguars remain in Mexico in 1970 and have an estimated 0.82 reproductive rate, the average annual decline in skins received in the U. S. fur market, 1968-70 (36%), suggests 1991 as the year of the last jaguar. Similarly, if 350 cougars live in New Mexico in 1970, a 29% annual overkill will extirpate them in 1990.

Yellowstone grizzlies have a 0.56 reproductive rate and immaturity period 1.7 times that of the cats. If natural mortality drops to 7% in the first year, a widely cited figure after closing of the garbage dumps, the 250 bears will stabilize with a 10.2% annual kill or removal for management purposes.

We urge park managers and multigovernmental (park-state) planners to consider the predictions of computer models in controlling culprit carnivores and issuing hunting permits.

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POPULATION STUDIES OF THE BLACK BEAR IN THE GREAT SMOKY MOUNTAINS  
NATIONAL PARK

Pelton, M. R.

Since 1970, over 7000 km of trails have been hiked, 2100 scats collected, and 190 captures made on 123 individual black bears in the SW quarter of the Park. Data on population density, reproduction, age structure, food habits, movements, and activities have been gathered.

Using the techniques of capture-recapture and radioisotope-feces-tagging, a population estimate was derived of one bear/2.6 km<sup>2</sup> (and stable); smaller, interior areas support population densities of twice this figure. Observations of 100 females with cubs revealed an average litter size of 2.1; reproductive histories of adult females indicate the frequency of litter bearing is below biotic potential. Analysis of cementum annuli of premolar teeth of 118 bears indicate an average age of 4.1 yr for males and 6.4 for females; adults (>4 yr old) made up 68% of the population.

Analysis of over 1100 scats revealed a predominantly vegetarian diet consisting of various herbaceous plants in spring, a wide variety of soft mast in summer, and hard mast in fall; during years of poor hard mast production bears move long distances in foraging and thus, become more vulnerable to mortality factors. Sizes of summer home ranges of 22 radiotracked bears averaged 681 ha for 10 females, 642 ha for 6 subadult males, and 110 ha for 6 adult males.

Activities such as denning, panhandling, marking trees and making summer beds are discussed. Major factors contributing to relative population stability are delineated.

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A FUNCTIONAL AND SONOGRAPHIC ANALYSIS OF THE MOANING VOCALIZATION  
PERFORMED BY BLACK BEARS (*URSUS AMERICANUS*)

Jordan, Robert H.

Various moans, whines, and screeches performed by black bears were described and analyzed sonographically. Data are presented to support the hypothesis that these vocalizations all communicate a message which, translated into plain English is "Allow me to perform this action!". There are gradations of the basic message. At one end of the continuum the message is: "Please allow me to perform this action!". At the other end the message is: "I demand that you allow me to perform this action!".

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DO BLACK BEARS (*URSUS AMERICANUS*) MARK?

Jordan, Robert H.

Rubbing, urinating, defecating, and sniffing behaviors performed by seven captive black bears were selected for analysis from 145 of direct systematic observation and many additional hours of films and videotapes. The behaviors were related to their behavioral and environmental contexts to determine whether they might serve territorial, sexual, or dominance functions.

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POPULATION STUDIES OF THE EUROPEAN WILD HOG IN THE GREAT SMOKY  
MOUNTAINS NATIONAL PARK

Pelton, M. R.

Data on food habits, reproduction, age structure, blood parameters, and control techniques were analyzed from over 200 European wild hogs removed from the Park between 1971 and 1975. In addition 1419 rooting sites and 48 wallows were recorded by hiking 105 km of index routes monthly; feces, wallows, and streams were monitored for bacterial contaminants.

Stomach contents of 128 hogs revealed primarily plant material in all seasons (90.2% by vol); mast was important when available. Apparently no reproduction occurs during years of poor mast production and during such years more extensive rooting and disturbance on understory vegetation likely occurs. Reproductive tracts from 162 hogs revealed that puberty is attained in males at 7-12 mo and females at 4-7 mo; males are physiologically capable of breeding year-round. The ave. litter size was 3.0 with farrowing peaks in Nov-Dec-Jan and again in May-June-July and one litter/female/yr. Utilizing a combination of aging techniques the ave. age of hogs was 1.5 yr; the age structure indicated an expanding, healthy population. Analysis of 20 blood parameters from 70 hogs revealed close similarity with domestic hogs and no reliable techniques for monitoring population condition.

A bacteriological survey indicated that rooting and wallowing activity may be contributing to bacterial loads of streams. Root site evaluations revealed distinct seasonal movement patterns and resulted in establishing a rooting-extent-index for future monitoring of the population. An evaluation of conventional control techniques revealed that shooting was the most efficient means of removing hogs.

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BEHAVIOR OF THE EUROPEAN WILD BOAR IN THE GREAT SMOKY MOUNTAINS  
NATIONAL PARK

Shaffer, Mark L.

This was a preliminary survey of boar behavior in high and low elevation habitats during the summer season. Information was gathered on the size, composition, and fidelity of groups; their daily activity and movement patterns; habitat utilization; and individual and group interactions.

An attempt was also made to bait boars to pre-selected sites to be photographed. The photographs were then used to make a population estimate for the study area.

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## THE FERAL PIG IN HAWAII VOLCANOES NATIONAL PARK

BAKER, James K.

The non-native feral pig in Hawaii and the Hawaii Volcanoes National Park is a major disruptive component of the native rain forest and grassland habitats. The exotic pig was first introduced to Hawaii by early Polynesians more than 1,200 years ago.

European breeds of pigs were introduced to Hawaii in 1778 by Captain James Cook and during the nearly 200 years since that time, a large number of pigs of a wide variety of domesticated breeds have been brought to the islands.

The pig is an omnivore and a scavenger. In the rain forest and grassland communities of the park, it feeds on vegetation, insects, earthworms, ground nesting birds, eggs and rodents. It commonly scavenges on remains of cattle, goats and other pigs. In the rain forest, its chief diet is the starchy interior pulp of the tree fern.

The pig's habits of hollowing out interiors of tree ferns and making mud wallows creates micro-aquatic habitats for mosquitoes, other insects and various small crustacea. Because pigs create mosquito habitat in areas where these insects would not normally occur, the pig through spread of mosquito borne avian malaria and birdpox is an indirect threat to the extinction of native birds.

By the making of trails, mud wallows, mosquito habitat, and by its rooting activities, tusking of tree trunks and by its role in spreading weedy, non-native plant species, the exotic pig in Hawaii is also endangering native forest and grassland communities.

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THE BEHAVIOR, ECOLOGY, AND SOCIAL ORGANIZATION OF THE FERAL PONIES  
OF ASSATEAGUE ISLAND

KEIPER, RONALD R.

Approximately 200 ponies live on Assateague Island, a 37 mile long barrier strand that parallels the Atlantic coast of Maryland and Virginia. Since June, 1975, over 1000 hours of direct field observation have been conducted on these animals and significant data has been collected on their behavior, ecology, and social organization. Despite the fact that the ponies live within the Assateague Island National Seashore, they lead a relatively wild existence, roaming freely about the island and obtaining their own food throughout the year. Socially the ponies are organized into distinct herds. Most herds consist of a dominant stallion, 2-15 mares, and their offspring. Some herds contained other males in addition to the dominant stallion, while other herds had no dominant stallion at all. Two of the herds were small bachelor male groups. The dominant stallion did not always control the activities and movements of his herd. Often a mare led the herd during grazing and in long distance movements to water or resting sites. Many herds were unstable, with individuals moving from herd to herd or wandering by themselves for extended periods of time.

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## ECOLOGICAL STUDIES OF FERAL BURROS IN DEATH VALLEY

Douglas, Charles L. and Norment, Christopher

A herd of 1500 feral burros inhabits mountain ranges on the western side of Death Valley. These animals cause severe management problems by destruction of vegetation and competition for resources with other mammals.

A large scale marking and telemetry program is underway to determine seasonal movements. More than 80 individuals have been marked. Marked animals are monitored from ground and aerial surveys. Movements are being correlated with phenological changes in major browse plants. A double-sampling technique is used to assess the biomass of vegetation consumed seasonally. Nutrient levels and caloric content of important browse species are analyzed at monthly intervals.

Population structure and dynamics are being assessed, and parameters such as growth and aging also are being studied. The effect of burros on populations of small mammals is being evaluated by means of two trapping grids. An ancillary study has resulted in establishing hemotological and physiological standards for Death Valley burros. Currently, an electrophoretic study of serum proteins is helping assess population genetics and the relationships of Death Valley burros to those outside the Monument.

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FERAL BURRO MANAGEMENT AT BANDELIER NATIONAL MONUMENT, NEW MEXICO

FLETCHER, M. R.

Feral horses and burros in the west have shown a dramatic increase in numbers in recent years since the passing of Public Law 92-195. Bandelier National Monument in northern New Mexico has had a population of feral burros since the late 1930's. Control of these exotic animals has been sporadic at Bandelier and no official control has been accomplished until 1975.

At that time, the population of burros at Bandelier National Monument was estimated to be approximately 130 animals which ranged an estimated 8,000 hectares. An Environmental Assessment was prepared and filed and a decision was made to reduce the herd by approximately one-third. In February, 1975, shooters from the National Park Service reduced the herd by 52 animals. At the same time, radio collars were placed on eight animals and color-coded collars on another 11 animals. These marked animals were under close observation from May 1975 to May 1976.

Research activities on the burro herd have included soils studies, vegetative analysis and vegetative trends, deer-burro interaction studies, and two ethology studies of the herd. Soil erosion on the monument is severe with up to 30 tons of soil per acre (67,000 kg/ha) lost each year. Vegetative surveys of vegetative trends show more than 50% of the vegetation in a downward trend. Aerial surveys and information gained from marked animals indicated that the population is increasing by approximately 25% per year. In the summer of 1976, the herd numbered approximately 160 animals.

In June, 1976, the staff at Bandelier National Monument began preparation of an Environmental Assessment to review options on the management of the feral burro population at Bandelier. The Environmental Assessment will consider options from "No management" to "Removal of as many burros as is feasible" and will be available for public input by September, 1976. After public consideration, management will make the decision regarding population control of feral burros at Bandelier National Monument.

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INVERTEBRATE FAUNA OF THE EARTH CRACKS OF  
WUPATKI NATIONAL MONUMENT, ARIZONA

WELBOURN, W. CALVIN

The earth cracks of Wupatki National Monument are tectonic features associated with three grabens within the monument. Various aspects of these faults were investigated by the Cave Research Foundation at the request of the National Park Service. Five earth cracks were examined for invertebrate cave fauna, with 24 arthropods and one mollusk being found. Several earth cracks and caves in the vicinity of Wupatki National Monument were also examined for invertebrates and compared with the findings at Wupatki.

Examination of the fauna revealed 23 percent troglaphiles, 55 percent troglloxenes, and 22 percent accidentals. No troglobites were found in the Wupatki earth cracks. The caves and earth cracks examined outside the monument contained a higher percentage of troglaphiles as well as two species of troglobites. The most common invertebrates in the Wupatki earth cracks were cave crickets Ceuthophilus yavapai Hubbell and pseudoscorpions Pseudogarypus sp. and Archeolarca sp. A population study was conducted in one earth crack.

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A YEAR IN THE LIFE OF ORTHOPORUS ORNATUS, A DESERT MILLIPEDE

CRAWFORD, CLIFFORD S.

Orthoporus ornatus is a large, long-lived detritivore of the Chihuahuan and Sonoran deserts. Its role in desert ecosystems is appreciated by examining its behavior, reproduction, feeding, and dormancy in appropriate seasons.

Early summer rains promote massive emergence from soil hibernacula. Feeding on the soil surface and in shrubs during the next 3-4 months is enhanced by behavioral thermoregulation and exceptional resistance to desiccation.

Ova mature a month after emergence. Deposition of up to 500 eggs, each covered by a maternal fecal pellet, occurs in underground chambers. Hatching, early molt, feeding on pellet material, and emergence from the pellet usually occur within a year.

A population at Big Bend National Park ingests at least 13.7 megacal  $ha^{-1}$  in a summer while producing the cuticle-tissue equivalent of 2.0 megacal  $ha^{-1}$ , or less than 1% of the estimated net primary production. High assimilation efficiency correlates with ability to digest cellulose.

The subterranean habitat is reoccupied as feeding ends. Metabolism is depressed, and a switch from carbohydrate to lipid metabolism characterizes dormancy. In the next 2-3 months the full gut is emptied of most ingested material and water, while the cuticle-tissue complex becomes increasingly hydrated. Later hydration during dormancy appears due to metabolic-water production. Hemolymph osmolality is elevated significantly during dormancy, reducing the potential for water loss to relatively dry soil.

Annual molt in late spring directly precedes increased energy expenditure as the desert millipede prepares for another cycle of emergence, feeding, and dormancy.

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PRELIMINARY OBSERVATIONS OF THE BEHAVIOR AND ECOLOGY OF THE CAVE  
CRICKET (Hadenoeus subterraneus Scudder.)

\*STONEBURNER, DANIEL L. AND \*\*BARR, THOMAS C., JR.

This paper introduces a novel technique for "in situ" observation of cave organism behavior, both in and out of caves, and discusses the ecological importance of the cave cricket as an energy transport mechanism.

Historically, the aquatic and terrestrial biota living in the heterotrophic cave system at Mammoth Cave National Park had three major sources of energy: detritus transported into the system by vadose water percolating downward from the surface, material deposited by a migratory bat fauna, and material introduced by the cave cricket.

The demise of the bat fauna in the Mammoth Cave system left the cave cricket as the primary natural energy source for the terrestrial cave biota. Fiber optics were used to record the behavior of the cave cricket at extremely low light levels as its energy is dissipated along major energy pathways. Population studies using mark and recapture techniques and calorimetric determinations of cave cricket guano were used in a preliminary model of cave energetics in White Cave, an isolated segment of the Mammoth Cave system.

Crickets are scavengers, feeding outside the cave at night on the forest floor and roosting on cave ceilings by day. The migratory behavior of the cave cricket results in the annual introduction of about 1.3 to  $3.4 \times 10^5$  kilocalories in the form of cricket bodies, eggs, and guano. Preliminary observations indicate that cave cricket guano, ranging from 2-3.5 kilocalories per gram, provides the base for the energy budget in the terrestrial portion of the heterotrophic cave system.

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REPRODUCTIVE CHARACTERISTICS AND MANAGEMENT POTENTIAL OF  
THE SEA TURTLE ROOKERY AT CANAVERAL NATIONAL SEASHORE, FLORIDA

EHRHART, L. M.

The population of sea turtles nesting on the beaches of the Merritt Island National Wildlife Refuge (on the lands of the Kennedy Space Center) was studied in the summers of 1973, 1974 and 1975. Much of the shoreline included in the study is incorporated into the newly-created Canaveral National Seashore. Of the 288 sea turtles encountered and processed, 283 (98.3%) were loggerheads, Caretta caretta, and five (1.7%) were green turtles, Chelonia mydas. These are the northernmost records of green turtle nesting in the western hemisphere, and probably in the world.

The loggerhead nesting season begins in early May at Canaveral National Seashore, and lasts until mid- or late-August. The frequency of egg clutch destruction by raccoons is extremely high (nearly 100%) however, and in response to this, and in order to record basic reproductive data, we established a protective incubation hatchery in 1974 and 1975. Average clutch size for loggerheads at CNS is 110. Mean egg weights and minimum diameters are 42 g and 42 mm. Green turtle eggs are considerably larger at 60 g and 47.5 mm. The mean length of the incubation period for loggerheads (indoors) is 69 days. The fertility rate for loggerheads in 1975 was ca. 87%. In 1974, 4352 (85% of potential) loggerhead hatchlings and 124 (74%) green turtle hatchlings were released. In 1975, 3431 (72%) loggerheads and 40 (64.5%) green turtles were released.

Canaveral National Seashore holds considerable potential for sea turtle management and preservation in that it includes ca. 40 km of good nesting beach that can be well protected and controlled. A management program consisting of removal of eggs for protective incubation, raccoon removal, and/or protective enclosure of clutches on the beach is suggested.

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HERPETOLOGICAL RESEARCH IN THE NATIONAL PARK SYSTEM -- CRITERIA FOR APPROVAL AND POSSIBLE DIRECTIONS FOR FUTURE ENDEAVORS

MORAFKA, D. J.

The National Park Service should undertake an active, positive role in establishing standards for quality research, translating the results of that research into management decisions and educational programs, and ultimately in developing major themes for coordinated system wide investigation.

The following questions should assist in assessing the appropriateness and quality of research proposals:

- (1) Does the research have an adverse effect on Park herpetofauna?  
If so, (a) why must the investigator disturb a park protected population? (b) has the potentially negative impact been minimized without impairing accuracy and significance of the investigation?
- (2) Is the experimental design, sample size, funding, and schedule of the proposal realistic, relative to the objectives?
- (3) Is the theoretical or practical importance of the proposal's objective sufficient to justify anticipated burdens imposed upon park resources and/or staff?

Park administration should also encourage coordinated, system-wide projects that benefit both individual herpetologists and the needs of the park service. Herpetological investigations on the following major themes are recommended:

- (1) The uses of amphibians and reptiles as ecological indicators relative to: communities, climatic zones, successional stages, biogeographical provinces, and pollution (toxicity, disclimax, etc.)
- (2) Conservation of threatened species.
- (3) The evaluation of individual species through niche definition, especially the dominants, the community organizers, and the generators of microhabitats. Reducing public prejudice against these classes through such studies.
- (4) The inventory of indigeneous herpetofaunas system-wide (keys, checklists). Such efforts should focus on ecosystem structures and biotic provinces more than on political boundaries.

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## APPLICATIONS OF ISLAND BIOGEOGRAPHIC THEORY TO NATURE PRESERVES

Harris, L. D. and Miller, R. M.

The theory of island biogeography explains the species diversity and dynamics of insular biota. Application of island biogeographic theory to nature preserves builds on the proposition that preserves are fast becoming isolated islands in seas of civilization. Two case studies, the Mkomazi Game Reserve of northern Tanzania and the Everglades National Park are reported.

Fundamental to island biogeographic theory is the premise that the number of resident species is predictable from an allometric function of the area's size. Though the original species-area relation encompassed continental areas (such as preserves), recent empirical parameter values have derived from insular research. Our results suggest that these values are inappropriate for application to continental preserves.

To apply the theory to preserve situations special consideration must be given to the geographic region, the degree of isolation and the taxon being considered. Even though little relation exists between area and the present number of large mammal species in East African preserves, the species-area equation adequately predicts the number of extant everglades mammals. The model predicts a future equilibrium number for the Mkomazi which implies local extirpation. This is empirically confirmed to date.

Results suggest that other factors such as environmental heterogeneity and intrinsic community structure may be more important as predictors of the equilibrium number of species than area per se. The very rich trophic elaboration of the Everglades Park is crucially distinct from the East African case where virtually no biomass is positioned above the primary carnivore level.

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SPECIES ORIENTED MATRIX STUDIES TO INVESTIGATE TERRESTRIAL ECOSYSTEMS  
IN CANADIAN NATIONAL PARKS

CARBYN, L. N.

Large mammals are important components of the ecosystems in National Parks. Visitor pressures and evolutionary changes require that studies be designed to promote an understanding of the inter-relationships between mammals and their environment.

Funding and priorities dictate the scope to which such studies can be undertaken. In this paper, a model is presented that uses wolf/prey studies in Riding Mountain National Park as an example of how species oriented, matrix studies can be used to learn more about the functional interactions of species within natural systems. Biological diversity and biological originality are important management objectives for these systems.

Research is being directed at two levels. The first level concerns the interactions between predators (i.e. wolves) and prey. Predators and prey interact in a complex network of biotic and abiotic factors. Key factors must be isolated, studied separately and then synthesized. Predictions are made and evaluated through either observations (naturalistic approach) and/or instrumentation. The latter involves manipulating, handling and marking of mammals. Such techniques, when used in National Parks, must be carefully considered within the framework of parks policy and the philosophy behind non-consumptive resource conservation.

The second level of approach is then directed towards other related components within the ecosystems. Priorities going to those components which seem to most directly affect the predator/prey cycle. By using the carnivore population as a fulcrum for research, it becomes possible to better understand the interrelation of organisms at other trophic levels.

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DEPLOYMENT, DISPERSAL, AND ADAPTIVE STRATEGIES OF LAND VERTEBRATES  
ON ATLANTIC AND GULF BARRIER ISLANDS

LAZELL, J.D.

Reptiles, amphibians, and mammals have been studied on the offshore barrier islands at Cape Cod, Cape Hatteras, Cape Lookout, and Gulf Islands National Seashores. The numbers of resident species in these groups is less, usually an order of magnitude less, than on adjacent mainlands. Marked differences, often worthy of taxonomic distinction, tend to characterize barrier island populations. Special ecological relationships and novel adaptive strategies often develop in these vigorous and depauperate habitats. Although barrier islands are amazingly dynamic spatially and temporally, their ecosystems are solidly stable, resilient, and tenacious. Human interference with natural geological and botanical processes on such islands tends, therefore, to directly endanger unique, often endemic, vertebrate animal forms.

Land vertebrates reach barrier islands by three different routes: (1) direct overwater colonization from mainlands; (2) longshore dispersal concordant with sand movement; and (3), rarely, upstream dispersal across shoaling inlets. Of these, the second has tended to produce the highest rates of differentiation and levels of endemism.

The kingsnake-ricerat (Lampropeltis-Oryzomys) interrelationship, involving the waxmyrtle (Myrica cerifera) as refugium and hibernaculum, seems to be one of the most elegant, yet simple, adaptive strategies yet evolved.

Much additional work must be done to elucidate further adaptive strategies and determine the status of little-known forms.

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ECOLOGY OF ELK ON ALPINE TUNDRA IN ROCKY MOUNTAIN NATIONAL PARK

STEVENS, DAVID R.

The alpine tundra is one of the most unique resources in Rocky Mountain National Park. Increasing our knowledge of the natural influences and their relationships to man-caused impacts is important to the proper management of this resource. In recent years, elk have increased their use of the tundra as winter range. In 1976, over 300 elk wintered above 11,000 feet (3,353 meters) elevation. The primary objective of this study was to document ecological impact of elk populations on the alpine in both summer and winter. Data were gathered on elk food habits and vegetation type usage. Transects and agronomy cages were installed in 1971 to measure annual utilization and document composition and cover trends of the vegetation. The results of the five years of study are presented.

Rocky Mountain National Park  
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## A POPULATION MODEL OF THE NORTH YELLOWSTONE ELK

FOWLER, CHARLES W.

The nature of the data which has been collected during past studies of the North Yellowstone Elk herd has made it possible to construct a population model. Because of the interest in this herd, the model has been used to better understand its dynamics. The importance of any biases in the data was examined and alternative management strategies were compared. An assessment of the degree to which predation could act as a regulatory agent was made. Migration as a dynamic property of this herd was suggested to be important and was hypothesized to be density dependent. The model is a density dependent variable projection matrix.

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PERSPECTIVES ON THE MANAGEMENT OF AN INTRODUCED WAPITI POPULATION IN  
MOUNT RAINIER NATIONAL PARK

BRADLEY, WILLIAM P. AND DRIVER, CHARLES H.

National Park Service policy relative to the management of park wildlife must be based on a thorough knowledge of the species' biology. This is particularly true for large ungulates which have the potential to alter existing environments. Maintenance of desired environments in national parks will often require direct management efforts for controlling the abundance or level of impact of these species. Management efforts are often complicated, however, when ungulates utilize park areas only on a seasonal basis. This necessitates the cooperation of other agencies whose current policies and management goals may not correspond with those of the Park Service. Such is the case with the introduced Rocky Mountain wapiti in Mt. Rainier National Park.

A research program initiated in 1973 to provide biological baseline data for wapiti in Mt. Rainier environments is briefly described. This study has documented the physical impact of wapiti in the park and has provided data on wapiti-vegetation interactions. Analysis of data on wapiti population dynamics, movements, migration, distribution, and abundance within the park provide additional important management data.

A cooperative multi-agency management plan involving the Park Service, the U. S. Forest Service, and the Washington Department of Game is being prepared for Park Service consideration. This plan includes an analysis of the management potential of sport hunting on wapiti winter range outside the park. Other management alternatives and their relation to present Park Service policy are discussed and suggestions for policy changes are offered.

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## DESERT BIGHORN SHEEP IN CANYONLANDS NATIONAL PARK

DEAN, H. C.

Canyonlands national park harbors one of the few native desert bighorn sheep (*Ovis canadensis nelsoni*) populations in the United States. This study investigated the distribution of bighorn sheep in the Park and the role landforms played in the bighorn sheep-livestock conflict.

Canyons within the Park were classified into four types on the basis of characteristic landforms. Botanical characteristics and water sources were evaluated for a minimum of two canyons for each type. Interviews with cattlemen were employed to determine the historical bighorn sheep distribution and the extent of livestock grazing. Present bighorn sheep distribution was determined by periodically surveying representative canyons throughout the study.

Prior to intensive livestock grazing bighorn sheep occupied much of the Park. Today they inhabit only those canyons which are entirely inaccessible to livestock or canyons which have physical barriers preventing livestock from utilizing much of the canyon. Bighorn sheep and deer demonstrate a similar spacial separation. If bighorn sheep actually prefer rugged terrain, they would be selecting areas which are more energetically costly than other available habitats. It appears that they are selecting for isolation rather than a preferred terrain type. Possibly it is this need for isolation which has made the desert bighorn sheep a relict species.

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MOVEMENTS OF DESERT BIGHORN SHEEP IN THE RIVER MOUNTAINS OF THE LAKE  
MEAD NATIONAL RECREATION AREA

Leslie, David, and Douglas, Charles L.\*

Since 1973, a total of 82 individual sheep have been marked with color-coded ear or neck tags. Ten animals were equipped with radio telemetry collars to facilitate intensive study of their movements.

To date, 850 observations have been collected by means of ground survey, waterhole counts, helicopter and fixed wing surveys. A total of 201 observations were recorded on the radio equipped animals in the period between July 1, 1975 and November 30, 1975.

Preliminary findings on movements indicate a smaller home range for ewes (particularly those with lambs) and a larger range for rams, that increases in size with age of the individual. Demography of the River Mountain herd is being evaluated, as is population size and dynamics.

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EWE-LAMB VOCALIZATION AND RECOGNITION IN CAPTIVE BIGHORN AT  
ZION NATIONAL PARK, UTAH

MCCUTCHEN, H. E.

Ewe-lamb vocalization and recognition phenomena are described in a herd of captive desert bighorn sheep.

Ewe vocalizations were uncommon and were detected only within a time period of two months post-partum. The vocalization frequency decreased toward the end of this period. Ewe vocalization was related to the need of a ewe to locate her lamb for nursing among other lambs or when it had moved in rugged terrain. Observations are presented which indicate individual recognition of maternal calls by the neonates. Ewe vocalizations may play a part in reinforcing mother-infant social bonds and prepare the lambs to follow the ewes away from lambing grounds.

Lamb vocalizations were rare. There was no evidence to indicate individual recognition of lamb calls on the part of the ewes.

Individual recognition by visual and olfactory means related to nursing behavior are discussed.

Zion National Park  
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## DALL SHEEP DEMOGRAPHY IN MCKINLEY PARK

MURPHY, E. C.

Adolf Murie's classic wolf studies in Mount McKinley National Park from 1937 to 1941 included detailed analysis of the Dall sheep (Ovis dalli) population. His data have been analyzed and cited in numerous papers on mortality patterns in mammals and in several ecological textbooks. The present report includes a reevaluation of these data and presentation of additional demographic data collected through 1972. The role of National Parks as sites for such studies is discussed.

Dall sheep population numbers, age-sex composition, and the male age structure were studied in McKinley Park in the summer, 1972. Ages of 142 living males were estimated by analyses of photographic transparencies. This sample, with the composition ratios, was used to determine the male age structure. Results indicated that the age structure had not been stationary over the past several years. Reanalysis of the skull data collected by Murie showed that the age structure had not been stationary in the 1930's. Life tables constructed from his data are then time-specific. Additional problems inherent in life tables constructed from these skull data are discussed.

McKinley Park is one of only a few areas where Dall sheep, one of the most sought-after big game trophies, are not hunted by man. It is an ideal site for studying Dall sheep in relatively undisturbed conditions. But demographic parameters vary considerably not only temporally within a locality such as McKinley Park but also geographically. A wide spectrum of Dall sheep habitats, from the Wrangell Mountains to the Brooks Range, should be preserved in the National Wilderness System.

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MOUNTAIN GOAT - HIGHWAY RELATIONS ALONG U.S. HIGHWAY 2,  
GLACIER NATIONAL PARK

SINGER, FRANCIS J.

U.S. Highway 2 enters Glacier National Park for 5.2 km (3.2 miles) and traverses a movement route for mountain goats (Oreamnos americanus) visiting a natural mineral lick on the banks of the Middle Fork of the Flathead River. A Study was conducted in 1975 to obtain data on the mountain goats and surrounding environment in order to form a basis for options in a proposed highway reconstruction. Data was gathered on reactions of goats to traffic, human-goat interactions, seasonal and daily crossing patterns, and adaptations of goats to the traffic/visitor situation.

An estimated 24,000 vehicles and 66,000 visitors stopped at the exhibit in 1975; as many as 39,000 people may have seen goats at the lick. From 0-40 percent of the passing traffic stopped at the lick, the higher rates occurring during midday. Traffic safety hazards approached .5 violations per hour at the exhibit during the peak of visitor season.

A high rate of disturbances by passing traffic and visitors occurred during goat crossings. Crossing goats responded to disturbances by hesitating, running back from the edge of the highway, running across the highway, and/or altering their crossing route. Successful highway crossings were significantly associated with a crepuscular pattern, size of crossing group, and sex and age of the group leader. Only 0-2 mountain goats are hit by vehicles each year because, 1) most goats cross the highway when traffic volume is the lowest, 2) goats hesitate or run back from the road edge when vehicles pass, and 3) drivers are able to avoid goats that do run across because of slow speeds ( $\bar{x} = 25$  mph) in the crossing area. Reconstruction was decided upon to include two goat underpasses of the highway in order to avoid goat-vehicle collisions at the higher reconstruction speeds and to avoid further nanny/kid separations during crossings. In addition, the visitor viewing area will be relocated to the east to avoid disruption of goat movements and to eliminate the human safety hazards associated with the present roadside location.

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ECOLOGICAL RELATIONSHIPS OF MOUNTAIN GOATS (*Oreamnos americanus*) IN  
GLACIER NATIONAL PARK

CHADWICK, D. H.

Data are presented from a three-year (1974-76) study of mountain goat ecology in a 310 km<sup>2</sup> study area in Glacier National Park. Supplementary and comparative data are drawn from a previous three-year investigation of goats in the Swan Mountains of adjacent Flathead National Forest. Regular field surveys of goat ranges were accompanied by intensive observation of selected herd units and quantitative examination of social behavior.

Comprehensive field surveys showed that a stable population of approximately 360 mountain goats inhabited the park study area yielding an unexpectedly high density of 1.2 goats/km<sup>2</sup>. These results and sample surveys elsewhere in the park suggest that parkwide population figures are closer to 1,500 than to traditional estimates of 600-800 goats. Mountain goat habitat relationships were found to be determined primarily by physical parameters associated with primary (geological) succession rather than secondary (plant community) succession. Goats exhibited marked preferences for steep slopes, high elevations, and rock outcroppings in all months. During winter, rock ledges provided 88% of all foraging and 97% of all bedding sites. Occupation of a topographically defined, narrow niche appears to have selected for utilization of habitats within a limited range of climax alpine and subalpine plant communities, plasticity of diet and foraging technique, and semi-gregarious social tendencies in this species. Monthly average group size varied between 1.8 and 5. Thirty-six percent of all goats observed in the park were alone or in pairs. Groups were widely spaced within habitats, with average minimum intergroup distance varying between 221m and 577m. Analysis of 4,000 behavioral interactions revealed that group size, structure, and distribution were regulated by agonistic relationships within a social hierarchy. Mortality patterns were similarly influenced by terrain-related factors. In 20 instances where cause of death could definitely be determined, avalanches accounted for 60% and climbing accidents for 15%. Climbing accidents were implicated in 64% of 53 observed physical abnormalities in live animals. Utilization of precipitous habitats in the early stages of primary succession was found to effectively isolate goats from the influence of predators and competitors.

In conclusion, this study indicates that mountain goat populations in Glacier Park are stable and naturally regulated by extrinsic abiotic factors; principally climate and the nature of post-glacial terrain inhabited by the species. Unique morphologic and behavioral adaptations and a complex social structure enable mountain goats to achieve high population densities within the carrying capacity of a specialized and physically demanding niche.

Glacier National Park  
West Glacier, Montana

ARTIODACTYL DISTRIBUTION AND ENVIRONMENTAL GRADIENTS,  
GLACIER NATIONAL PARK

ACKERMAN, BRUCE A. AND SINGER\*, FRANCIS J.

Winter observations of five species of artiodactyls, moose, elk, white-tailed deer, mule deer and mountain goats were plotted along axis of environmental gradients to determine the usefulness of the technique for studies of niche and habitat. A total of 920 observations from two study areas in the western half of the Park were analyzed. Environmental gradients evaluated were slope, elevation, time since burn, hydric/fluvial succession, snow depth, primary succession and topographic moisture. The gradients were established from plant ecology studies. Distributions of moose, white-tailed deer, and mountain goats were distinct from each other when plotted along the gradient pairs, slope - snow depth, topographic/moisture - elevation, and snow depth - fluvial succession. Elk and mule deer were more generalized in their distribution. Mountain goat distribution was best described by primary succession gradient. Sampling problems became obvious in the preliminary attempt, but the technique showed potential for studies of niche and for habitat predictions with artiodactyls.

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STATUS AND CHARACTERISTICS OF ARTIODACTYL POPULATIONS IN  
GLACIER NATIONAL PARK

MARTINKA, C. J.

Evaluation of historical records and current field studies reveal that eight species of artiodactyls are native postglacial inhabitants of Glacier National Park. Human encroachment resulted in extirpation of mountain bison (*Bison bison athabascae*) during the early 1800s and woodland caribou (*Rangifer tarandus caribou*) in the 1930s. Populations of mountain goats (*Oreamnos americanus*), bighorn sheep (*Ovis canadensis*), mule deer (*Odocoileus hemionus*), and moose (*Alces alces*) continue to occupy suitable park habitats to the present time.

Parklands encompass 41,000 km<sup>2</sup> of rugged mountainous terrain with principal habitats represented by streambottom forests, grasslands, upland coniferous forests, shrubfields, and alpine tundra. Wintering artiodactyls utilize this complex in relation to temporal, climatic, physiographic, and/or biological factors. Each category contains one or more environmental gradients which holistically determine distribution and numbers of wintering artiodactyls. The result is a predictable pattern of winter distribution based on specific habitat elements required by each species. In turn, relative numbers of each species are determined by the amounts of suitable habitat available within the park.

Each artiodactyl species is adapted to efficiently exploit a definable segment of one or more environmental gradients. The process of competitive exclusion apparently contributes to habitat and niche separation over time. Evolved physical and behavioral features effectively maintain separation in a static environment. However, time acts as an independent gradient to determine direction and magnitude of change in various dependent gradients. Accordingly, environmental gradients may be a useful tool in predicting future conditions or evaluating management options in the park.

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## JUNCO HABITATS IN THE WESTERN UNITED STATES

Haldeman, J.R.

Habitat characteristics were measured in 100 Dark-eyed Junco territories and 150 Gray-headed Junco territories. Dark-eyed Juncos were studied near Crater Lake and Diamond Lake, Oregon; and near Tahoe, California; while Gray-headed Juncos were studied near Las Vegas, Nevada, and Death Valley, California; Grand Canyon and Flagstaff, Arizona; and Luna, New Mexico.

Fifty-five habitat characteristics were determined for each junco territory; these were mainly vegetational factors with emphasis on ground cover, canopy cover, shrubbiness, and number of trees present.

From the methods used for sampling and the characteristics selected, it was shown that most of the characteristics remained consistent from one population to another and one species to another. The only single characteristics useful in separating populations were ground cover and lower canopy height, although other populations were separable by combined variables. All populations were significantly different from each other in their habitat configuration except Gray-headed Juncos in New Mexico and Dark-eyed Juncos in Oregon.

Variation in habitat configuration was small in Dark-eyed Juncos but large in Gray-headed Juncos. There was a greater difference between extreme populations of the Gray-headed Junco than between adjacent populations of Gray-headed Junco and Dark-eyed Junco. The smallest amount of habitat variation existed between the extreme populations studied, the Gray-headed Junco in New Mexico and the Dark-eyed Junco in Oregon.

There are no consistent habitat similarities within junco taxons and no consistent big differences between taxons, which supports those taxonomists who believe that the taxons considered are not true species.

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COLIMA WARBLER STATUS AT BIG BEND NATIONAL PARK, TEXAS

WAUER, R.H.

The total range of the Colima Warbler (Vermivora crissalis) in the United States occurs above 5500 feet elevation in the Chisos Mountains of Big Bend National Park, Texas. Studies of the bird's density, distribution and habitat preference, from 1967 to 1976, indicate that, although it is a peripheral species, its status within the Chisos Mountains is secure.

Six May Colima Warbler counts were taken during the study period, and populations ranged from 37 to 58 pairs. Density correlated to the amount of precipitation recorded during the months prior to and during the nesting season. The greatest variation of distribution was found to occur in fringe areas along the lower and higher elevations of the preferred canyons.

Approximately 85 percent of the territorial birds recorded were located along relatively narrow and moist canyons. Fifteen percent of the singing birds were located on relatively open slopes or ridges. Dominant to subdominant vegetation within 50 feet of eleven nests studied consisted of, in order of importance, Emory oak, bigtooth maple, Arizona cypress, drooping juniper, mountain sage, birchleaf buckthorn, Mexican pinyon, skunkbush sumac, and silktassel.

As a general rule, Colima Warblers were widely distributed in wet years and the highest populations occurred following a year of above average precipitation.

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CONCENTRATED AVIAN UTILIZATION OF AN EARLY FLOWERING CENTURY PLANT  
(AGAVE HAVARDIANA)

NEILL, R. L. AND ALLEN, T. M.

Highly concentrated avian activity was observed on the first flowering century plant in the Basin of Big Bend National Park from 19 May to 22 May 1976. Of the twenty-one species observed within 50 m of the Agave twelve utilized the plant as a food source, territorial post or perching site.

The study plant, located in the upper sotol-grassland association, had three inflorescence clusters in flower with the remaining twelve branches not yet flowering.

Four hundred sixty-eight avian visits were recorded in 18 hours of observation distributed over four days. The total time on the plant by avian species was 20,057 seconds or thirty per cent of the total observed time. Eighty per cent of the total combined activity was spent in feeding. Lucifer Hummingbirds (25%), White-winged Doves (25%), Blue-throated Hummingbirds (21%) and House Finches (13%) were the major species feeding on the Agave. Blue-throated Hummingbirds (42%) and Lucifer Hummingbirds (28%) accounted for more than half of the total number of visitations. The accelerated activity diminished by approximately half as other Agave plants came into flower, and as certain species relocated elsewhere in the Basin. All species recorded were resident species with the possible exception of Rivoli's Hummingbird.

Agave nectar with associated small insects served as the food source for ten species of birds. Nectar production in individual flowers were measured and peak production occurred between twelve midnight and six A.M. Nectar composition and concentration were analyzed using the anthrone test, ninhydrin reagent,  $\text{FeCl}_3\text{-K}_3\text{Fe}(\text{CN})_6$  and appropriate chromatographic procedures.

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AVIFAUNAL ASSOCIATES OF AGAVE HAVARDIANA TREL. IN BIG BEND  
NATIONAL PARK

ALLEN, T. M., NEILL, R. L.

This study reports the pattern of avian utilization of the Big Bend Century Plant, Agave Havardiana Trel., in Big Bend National Park.

All plants studied had the same number of branches and were found between 1554-1615m in elevation. The influence of light intensity and temperature was studied. Campground associated plants had a similar activity pattern to those in the natural ecological association except that House Finch activity was much greater in the campground area.

Data was gathered over 316 hours in two summers (1975 and 1976). Maximum avian activity, in general, occurred during the morning hours of 8:00-10:30 a.m. and the early evening hours of 6:30-8:30 p.m. Time separation between certain species with regard to their peak visitation times was evident. For example, hummingbirds visited earlier in the morning and later in the evening than the House Finches. A total of thirty-eight species of birds were observed utilizing the century plant. Plant usage was divided into categories of feeding, perching and singing with dominant species in the first category being House Finches, Black-chinned Hummingbirds, and Ladder-backed Woodpeckers; in the second, House Finches, Cactus Wrens, and White-winged Doves; and in the third category, Cactus Wrens and House Finches. These species are listed in order of descending importance. Flower parts, nectar, and flower associated insects were the major avian food sources offered by the plant. Agave Havardiana was often defended by territorial hummingbirds and used as a lookout post for territorial defense and predation by hummingbirds (i.e., Black-chinned and Lucifer Hummingbirds) and other bird species (i.e., Cactus Wrens and Ash-throated Flycatchers).

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## WADING BIRD PRESERVATION IN EVERGLADES NATIONAL PARK

KUSHLAN, JAMES A.

Fifteen species of wading birds nest in Everglades National Park. Concern for the future of the outstanding wading bird colonies located in the southern Everglades contributed to the park's establishment. The changing status of these species suggests failure of the habitat protection provided by the park to perpetuate their natural distribution and abundance. The options open to achieve perpetuation of these species and the ecosystem on which they depend within the park are complex and involve unresolved issues in the preservation of natural reserves.

Southern Florida wading bird populations have declined to about 5% of their late 1800's level because of colony disturbance and later habitat loss. Declines were generally confined to inland colonies. Some populations have increased. Regional changes after 1960 reflect continued habitat loss and altered hydrologic conditions, the critical importance of which is particularly demonstrable in the Wood Stork. Sharper declines occurred in populations nesting in the park owing to colony site shifts in response to overall functional segmentation of the southern Florida wetland system of which the park is only a part.

It is not possible to restore the conditions extant when white man first visited the park area. Population shifts away from the park evidence habituation to changing conditions which, if further changes were minimized, should establish a regional equilibrium in which inland portions of the park might be an insignificant factor in maintaining nesting populations. Some species may be extirpated from the park or the region. Complex additional hydrologic manipulation might restore a more naturally functioning system, which may or may not avoid loss of species components. Massive manipulation might preserve the most threatened species. A dilemma in perpetuating a large, but ecologically nonisolated reserve, is that attempting to preserve natural processes may not be compatible with maintaining maximum or historic species richness.

Everglades National Park  
Homestead, Florida 33030

WHITE PELICAN REPRODUCTIVE FAILURES IN THE MOLLY ISLANDS BREEDING COLONY IN YELLOWSTONE NATIONAL PARK

DIEM, KENNETH L.

Observations of the only White Pelican breeding colony in a national park and the only breeding colony of the species located at an elevation of 2357 m. began in 1890. From observations of the colony's production of young during 25 years between 1889 and 1967, an average of 208 juvenile pelicans were recorded annually. During 8 years between 1966 and 1976 the observed annual average of young White Pelicans declined to 71 birds. The 1970 breeding season was the first total breeding failure recorded for the Molly Island colony. Since 1970 two more breeding seasons have been complete failures. The reproductive failures appear to be the result of a complex interaction of several factors. Sublethal levels of DDE and PCB were measured in eggs collected in two of the years when complete breeding failures occurred but no egg shell thinning was detected. Marked decreases in nest building and increases in nest and young abandonment seemed to characterize the years of reproductive failure. These atypical behavior patterns appeared to be the result of increased stress produced by the integration of a constant body burden of pesticides with various combinations of delayed ice melt, cold air temperatures, high water runoff levels and unseasonable forms of precipitation. Disturbance of the colony by humans was considered to be negligible.

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THE COLUMBIAN SHARPTAILED GROUSE: WITH SPECIAL REFERENCE TO THEIR  
POTENTIAL REINTRODUCTION TO LAVA BEDS NATIONAL MONUMENT

STARKEY, E. E. AND SCHNOES, R. A.

Early settlers found Columbian sharp-tailed grouse (Pediocetes phasianellus columbianus) to be one of the most abundant game birds in shrub-steppe portions of the Pacific Northwest and Intermountain West. Today, they are only present in greatly reduced numbers in a limited number of locations. The subspecies is classified as "status undetermined" by the U.S. Fish and Wildlife Service. This paper discusses the causes of the population decline, current status of populations, and the potential reintroduction of the Columbian sharp-tail to Lava Beds National Monument, in northeastern California.

Population declines generally began with human settlement. Certainly overgrazing, farming practices and hunting were involved in the sharptail's demise. In addition, changes in habitat resulting from fire suppression could have been important. An attempt has been made to place these factors in perspective.

Present populations are in general decreasing or stable throughout the remaining range of the subspecies. A survey of state and provincial game agencies indicates that consideration should be given to reclassification of the Columbian sharptailed grouse from "status undetermined" to "threatened".

Columbian sharptail grouse were present in the Lava Beds area during early settlement periods. Therefore, their reintroduction to the monument is being considered. Potential habitat has been located and evaluated. Early vegetation maps were studied and promising areas sampled for frequency and density of plant species, as well as canopy coverage of shrubs. These data are compared to similar data from areas where sharptails persist. Habitat management recommendations are discussed. Additional research needs, primarily behavioral, are also presented.

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PEREGRINE FALCON REINTRODUCTION POSSIBILITIES ALONG THE SOUTH SHORE OF  
LAKE SUPERIOR

ISAACS, F. B. AND SLOAN, N. F.

Attempts at reintroducing captive bred peregrine falcons (Falco peregrinus) into abandoned eyries throughout the Eastern United States are currently underway. In 1974 the National Park Service provided funds for a study of peregrine history, current status and reintroduction possibilities in Department of Interior lands located along Lake Superior's south shore. The areas surveyed include Pictured Rocks National Lakeshore and Isle Royale National Park in Michigan and The Apostle Islands National Lakeshore in Wisconsin. The results of this study will be presented.

Historically, nearly all peregrine falcon nesting sites in this region were limited to lakeshore cliffs that provided suitable nesting ledges and access to sufficient prey. Between 1906 and 1962, 11 nests have been reported from five localities along the south shore of Lake Superior and on Isle Royale. In addition, nine nests have been located in four other areas of Michigan's Upper Peninsula. This data provided a nucleus for field studies aimed at determining current peregrine falcon status and at locating the site or sites best suited for a reintroduction attempt.

All eyries were found to be currently abandoned with no evidence of recent peregrine occupation visible. The Grand Portal Point area of Pictured Rocks National Lakeshore, occupied as recently as 1961, seems to provide the requirements necessary for a successful reintroduction attempt.

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FOREST FIRES AND THE TREE-HOLE NESTING CYCLE IN GRAND  
TETON AND YELLOWSTONE NATIONAL PARKS

TAYLOR, DALE L.

Natural (lightning caused) forest fires have been allowed to burn in zoned areas of certain national parks since about 1968. This paper is a report on bird populations that invade post-fire areas in Yellowstone and Grand Teton National Parks. Emphasis will be on the 3,106 acre 1974 Waterfalls Canyon Forest Fire in Grand Teton Park.

Northern three-toed woodpeckers were the most numerous nesting birds one year post-fire. Black-backed three-toed woodpeckers were also present, but fewer in number. Populations of both species were reduced by one-half in severely burned portions of the forest the second year post-fire. First and second year populations remained about the same in moderately burned areas.

The two woodpecker species initiate a tree-hole nesting cycle by making nest holes that are used by mountain bluebirds, tree swallows and other species. Hairy woodpeckers contribute to the tree-hole cycle from the second year post-fire until the end of the cycle. The cycle ends 30 to 40 years post-fire when all fire killed trees have fallen.

I conclude that northern three-toed woodpeckers, black-backed three-toed woodpeckers and mountain bluebirds are fire associated species.

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BIRD DENSITY AND DIVERSITY CHANGES FOLLOWING PRESCRIBED BURNING OF  
SAGEBRUSH (Artemisia tridentata) IN JACKSON HOLE, WYOMING

McGee, John M.

Wildlife responses to wildfire and prescribed burning are being studied in Grand Teton National Park and in adjacent areas of the Bridger-Teton National Forest. This paper reports changes in bird density and diversity immediately following spring and fall prescribed burning of a sagebrush community in Jackson Hole, Teton County, Wyoming.

In the first breeding season postburn, breeding bird density decreased markedly on both the spring and fall burn study areas. In the third year postburn, breeding densities on the spring burn area were approaching unburned-control levels. No species bred on the fall burn area during the first postburn breeding season, and only one species is known to have nested during the second season.

In contrast to the breeders, non-breeding birds increased dramatically following both burns. The greatest increase occurred on the fall burn area during the first growing season postburn.

Bird species diversity increased following spring and fall burning; the greatest value occurred on the spring burn area one season postburn. Variability decreased with time on each area. The increased diversity and variability resulted from the influence of non-nesting birds. This influence decreased with time in both cases. Three seasons following spring burning, diversity was similar to that obtained in unburned sagebrush. Species diversity on the fall burn area was slightly higher and more variable after two seasons following burning.

I conclude that spring and fall burning produce similar changes in density and diversity, but different rates of return to unburned levels.

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## COMPARATIVE ECOLOGY OF TWO AVIAN PREDATOR GUILDS

Eckhardt, Robert C.

Eight sympatric species of birds belonging to two insectivorous guilds (ecologically related groups) breeding at 2660m in Rocky Mountain National Park, Colorado, are examined in the light of theories of competition and predation. Flycatchers are used to exemplify the pursuers of optimal foraging theories, while gleaners (warblers) are used to exemplify searchers. The results of this investigation lend support to only a few of the many predictions drawn from several different models of optimal foraging. The concept of adaptive syndromes (coordinated sets of adaptations) is suggested as an alternative, and perhaps more useful, way of viewing predatory strategies, and the two adaptive syndromes revealed in this work are described.

The search/pursuit energy- or time- budget ratio, which is used to define searchers and pursuers, is demonstrated to be impossible to measure in the field for most species. Search-pursuit is therefore replaced by the concept of activeness of search, a spectrum of behavior ranging from highly active searchers (such as warblers; in some ways comparable to searchers or "widely-foraging" predators) to passive searchers (such as flycatchers; in some ways comparable to pursuers or "sit-and-wait" predators). Activeness of search is easily measured in the field by several different methods.

The adaptive syndrome exhibited by active searchers includes high velocity (perches/minute) and foraging intensity (attacks/minute), a small attack radius and foraging space, low diversity of structural foraging microhabitat, and small differences in critical morphological dimensions (wing, weight, bill) between species of the same guild. The adaptive syndrome exhibited by passive searchers includes low velocity and foraging intensity, a large attack radius and foraging space, a high structural foraging microhabitat diversity, and large differences in critical morphological dimensions between species of the same guild. Analysis of interspecific territoriality suggests that, in general, species respond to other species displaying the same general adaptive syndrome as greater potential competitors than to species displaying a different adaptive syndrome.

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THE INFLUENCE OF PREDATORS ON COLONY-SITE SELECTION AND REPRODUCTIVE  
SUCCESS IN RING-BILLED AND HERRING GULLS

SOUTHERN, W. E., CUTHBERT, F. J. AND PATTON, S. R.

Colonial waterbirds characteristically nest on islands and various selective advantages have been attributed to this phenomenon. In this paper we evaluate the effect of predators on breeding Ring-billed Gulls (Larus delawarensis) and Herring Gulls (L. argentatus). The resulting information is used to describe the optimum habitat required for successful reproduction by these species. Emphasis will be placed on the actual limiting effect of predators, particularly the red fox (Vulpes fulva).

During the summers of 1975 and 1976, the gull colonies on South Manitou Island, Leelanau County, Michigan, which is included in the Sleeping Bear Dunes National Lakeshore, were censused and monitored throughout the breeding seasons to ascertain the causative agents responsible for the previously noted high mortality rate. During both years we recorded extremely high natality and significant adult mortality. The primary cause in both cases was predation by red foxes. Surplus killing prevailed during most of the breeding season, particularly after young gulls were present. This resulted in several hundred gulls being killed in a single night, adults being frightened from the colony thereby exposing young chicks or eggs to near freezing nighttime temperatures, and apparent desertion by many pairs of gulls. Foxes were responsible for a significant part of the 85% mortality rate recorded for Ring-billed Gull chicks and the 99% rate for Herring Gull young.

We conclude that predator management is an essential part of any program designed to maintain ground-nesting colonial birds on protected Federal lands.

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VIII. SPECIAL PLENARY SESSION

MAPPING THE GRAND CANYON - National Geographic Lecture  
Washburn, Bradford

This public lecture, sponsored by the National Geographic Society, will introduce the audience, with color slides, to the topographic and geologic features of the central part of the Grand Canyon in Arizona, and will describe in detail a joint project of Boston's Museum of Science and the National Geographic Society to remap a part of the Canyon on a scale of 1:4800. A laser distance-measuring instrument used on this project will be demonstrated in the lecture hall.

Dr. and Mrs. Washburn have made 13 trips to the Grand Canyon of the Colorado River during the last 5 years, as a part of a joint project to remap 170 square miles of the heart of the Canyon, sponsored by the Museum and the National Geographic Society. The first survey of the Canyon was accomplished by Francois Matthes' extraordinary USGS expedition of 1902-03, which resulted in a map on a scale of 1:48000, published in 1903. The area was completely remapped photogrammetrically by the USGS in 1954 and 1960: the source of today's inch-to-a-mile Grand Canyon sheets.

Dr. Washburn's field work, involving nearly seven hundred helicopter landings, has produced a precise network of 92 control points on both rims and in the canyon. Measurements of distance were done with a Laser Ranger III under the direction of Harry R. Feldman. Angular measurements were made by Dr. Washburn with a Wild T-3 Theodolite. Photogrammetric plotting, based on this control and vertical aerial photography from an altitude of 16,000 feet, has been done by Lockwood Mapping of Rochester, New York, on 17 sheets at a scale of 1:4800 with 50-foot contours. Strip-maps of the trails, made with photographs taken from 12,000 feet, were contoured by Raytheon/Autometrics on a scale of 1:2400, with 25-foot contours.

The field work and photogrammetry are now complete, and research is now under way at the National Geographic, the Museum and the Swiss Federal Institute of Topography in Berne to determine the most effective way to present the incredibly savage and beautiful canyon topography. Publication on a scale of 1:24000 will take place by the National Geographic in about 2 years. Large-scale (1:5000) hikers' strip-maps of the trails will be published by the Museum of Science at about the same time. Simultaneously also, the Museum and Swissair Photo Vermessungen of Zurich are working on an extremely detailed and precise 1:5000 map of the Inner Canyon, which will be coordinated with all of the trail-strips which radiate to both the South and North Rims from this focal area.

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MODELLING SOUTH FLORIDA

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NO ABSTRACT SUBMITTED

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**NOTE:** Each registrant received a copy of the CONFERENCE ABSTRACTS as a part of the conference registration fee. The cost to *registrants* for additional copies will be \$5.00 per copy.

