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ABSTRACTS

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TABLE OF CONTENTS

ANTHROPOLOGY
- Anthropological Concerns in the National Parks 2-4
- Applications of Remote Sensing Techniques 5-10
- Archeological Research at Knife River Indian Villages National Historic Site 11-17
- Environmental and Archeological Studies in the National Parks 18-32
- Preservation Methods 33-37
- Recent Interpretations of the Anasazi Culture 38-40
- Recent Studies in Arctic Anthropology 41-50
- The Effects of Natural Impacts on Cultural Resources 51-52

AQUATIC BIOLOGY
- Aquatic Systems 54-61
- Fisheries Resources 62-70

ENVIRONMENTAL CONCERNS IN URBAN, IMPACTED PARKS
- Urban Environmental Studies 72-91

ENVIRONMENTAL EDUCATION
- Environmental Education 94-98

INFORMATION SCIENCES
- Resource Analysis and Mapping 100-123

PHYSICAL SCIENCES
- Atmospheric Resources 126-138
- Coastal Systems 139-144
- Earth Sciences 145-156
- Hydrological Studies 157-170

SOCIOLOGY
- Application of Social Science to Interpretation 172-173
- Backcountry and Wilderness 174-176
- Human Behavior and Planning 177-179
- Human Definitions of Parks and Recreation Settings 180-182
- Information Systems and Visitor Monitoring Programs 183
- Interaction Between Man and Animals in Parks 184-186
- Interpreting Trends for River Recreation Planning 187
- ORV's and Other Motorized Vehicles 188
- Parks as Social Systems 189-190
- Problems and Opportunities: The Case of the Park Visitor 191-193
- Putting River Recreation Research to Work 194
- Quality of Experiences in River Recreation 195-196
- Recreation Carrying Capacity: Management and Research Implications 197-198
- Social Adjustments to National Park Environments: Implications for Policy 199
- Special Populations in Parks 200
- Visual Perception of National Park Lands 201-204

SPECIAL INTEREST SESSIONS
Ecosystem Studies/Interdisciplinary Approach 206-213
Endangered and Threatened Species 216-233
Energetics Analysis/Systems Modeling 236-239
Exotic Species 242-265
Fire Ecology 268-296
Human Impact on Natural Resources 298-313
Human Impact on Natural Resources/ORV's 316-323
Origins and Development of the National Park Idea 326
Resource Management and Planning 328-343

TECHNOLOGY
Information Technology 346-360

TERRESTRIAL BIOLOGY: BOTANY, COASTAL BIOLOGY
Coastal Systems 362-367
Plant Ecology 368-379

TERRESTRIAL BIOLOGY: ZOOLOGY
Animal Ecology 382-390
Avian Studies 391-401
Mammal-Habitat Relationships 402-407
Mammal Studies 408-419

ANTHROPOLOGY

THE ROLE OF LIVING MEMORIES IN THE IDENTIFICATION AND INTERPRETATION OF CULTURAL RESOURCES

Ramsey, Eleanor Mason

Identification of cultural resources which represent the National heritage requires an understanding of the intrinsic meaning of a designated areas diverse ethnic and social heritage. This approach presents a number of sticky methodological problems under circumstances where the historical and ethnological record is either archival or unwritten. Reconstructing cultural history is, at best, a difficult task. However, oral history when broadly defined to include the recollections of living persons as well as the eye witness accounts of percipient witnesses, can be a valuable tool for retrieving unwritten cultural and historical data. A oral history research project conducted in Wilberforce, Ohio Spring 1978 in conjunction with a NPS suitability/feasibility study will be described in this paper to illustrate the application of this method in cultural resource management and new area studies.

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THE SOCIAL AND CULTURAL COMPONENTS OF "DAMAGE" TO PUBLIC LANDS:
THE INDIAN PEAKS WILDERNESS AREA (Front Range, Colorado)

KETCHIN, ANNE-FORREST

"Damage" as a concept has no specific definition which is not culturally relative. A "culture" may be as broad as "national culture" or as small as that of a group of scientists at a research station. An agency, such as the National Park Service, has a "culture" all its own, as do the many kinds of recreational users who may visit public lands. Behaviours in response to physical environment are based on beliefs and perceptions about that environment, and these are socially and culturally influenced. Therefore it is essential for sound management policy and planning that an understanding be attained of the complex relationships between behaviour and perceptions with regard to use of public lands. Particularly relevant in areas close to urban centers, such as the Rocky Mountain National Park and the Indian Peaks Wilderness Area, are behaviours and perceptions of "When damage has occurred" and what has caused it.

For this study a combination of techniques representing the methodology of Cultural Anthropology have beeen used to unearth this dimension. Through surveys, inventories, interviews, participant observation, and ethnographic documentation, all of which contacted back-country users, surrounding communities, involved agencies (USFS and NPS), and scientists (The Institute of Arctic and Alpine Research), an important regional picture has emerged. Data indicate that there is a high correlation between kinds of impact and the social and cultural environments of users, both that "at home" and while visiting the recreational area. Different drainages, ridges, etc. attract different "kinds" of users, both from a cultural and a recreational perspective, so that it is possible to compare and contrast drainages. In addition, management plans differ from drainage to drainage, making further comparison possible. The study has been funded by NASA grant number NGL 06-033-200 for the production of an Environmental Atlas of the Indian Peaks Wilderness Area.

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NEW DEVELOPMENTS IN NORTHWESTERN CALIFORNIA ANTHROPOLOGY: STUDIES IN REDWOOD NATIONAL PARK.

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Anthropological studies in Redwood National Park in 1978 and 1979 have produced noteworthy results in three areas, Native American consultations, human settlement pattern studies, and archaeological survey methodology.

Early in the planning stages of the park's General Management Plan, anthropologists consulted with Native Americans to obtain inventory information and recommendations regarding traditional use areas and sacred places within park boundaries. The consultations, which involved many more Native American individuals in park planning than has previously been customary in National Park Service efforts, amassed specific ethnographic data to which planners could respond, and resulted in the formation of advisory committees which provide for continuing communication between Native Americans and the park. The focus of these consultations was unusual in terms of anthropological study, in that areas of study were defined by park boundaries rather than by the total circumference of Native American familiarity; and the effort was to inventory places of ongoing traditional use and concern rather than to reconstruct old lifeways or to develop a well-rounded picture of the total lifeways of Native Americans presently living in the park area.

Archaeological survey in previously unsurveyed areas of the Redwood Creek drainage which now fall within park boundaries has accumulated considerable data which may be usefully applied to the study of settlement patterns in this area, and which will add substantially to our knowledge of the previously little-known Chilula, who inhabited this area ethnographically. Evidence accumulated to date fits well with parts of a currently proposed settlement model for the nearby Middle Eel area, and also suggests some variations in northern Chilula territory which could not have been anticipated from the existing ethnographic record of the Chilula.

The rehabilitation of logged slopes in the Redwood Creek drainage by Redwood National Park has opened a new methodological area for archaeology. In the past, logged slopes have often been neglected in archaeological survey for lack of funding or simply because it has been believed that archaeological sites could not survive logging, or even would not have existed in these (previously) heavily forested areas. Intensive survey of cat trails, logging roads and skid trails on logged slopes is resulting in the development of a new methodological approach to such situations, and is recording sites in previously unsuspected locales, such as on heavily timbered slopes well above the creek and well below the ridgeline.

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CULTURAL RESOURCES REMOTE SENSING IN THE EASTERN DECIDUOUS WOODLAND: EXPERIMENTS AT SHENANDOAH NATIONAL PARK

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While recent years have seen an almost exponential increase in the application of remote sensing methods to archeological and other cultural resource problems and research, the assertion is often made that aerial photos and other imagery are more useful to the archeologist in arid regions with little vegetative cover. This position probably springs from the fact that extensive prehistoric structures, common in the Southwest, are easily spotted with even medium-scale aerial imagery; not taken into account, however, is the fact that most prehistoric and historic cultural remains are nonstructural and relatively difficult to see even while walking on the ground, especially throughout most of the non-arid United States. This paper describes experiments undertaken in Shenandoah National Park directed toward the development of remote sensing methods for the cultural resource manager or scientist working in an eastern deciduous woodland environment. Seasonal differences in vegetative cover provide an opportunity for the examination of understory and overstory indications of site occurence on large- to medium-scale photographs, while aerial and satellite imagery are used as the basis of a predictive informed sampling stratification linking cultural resources with vegetative, geologic and other environmental information.

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PROJECTING ARCHEOLOGICAL SITE CONCENTRATIONS FROM COVER-TYPE MAPS DEVELOPED FROM REMOTE SENSING DATA

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Managing large areas of land requires knowledge of the locations of heavy concentrations of resources which must be protected. Methods such as environmental mapping from satellite imagery and computer graphic display will be discussed for projecting archeological site concentration estimates into areas which have not been previously surveyed.

Two methods of estimating archeological site concentrations from cover-type maps and existing or areally limited site information will be examined. Maps showing individual aspects of the environment, such as soils, geology, or vegetation can be used to develop individual, multi-staged, projections, with a final projection being made based on which aspect or combination of aspects proves to be the most accurate. The second method is to develop a cover-type classification from aerial or satellite remote sensing imagery which contains information on all aspects of the environment. This classification can then be used to develop projections of archeological site concentrations based on known archeological site data.

Specific examples of the two techniques from the San Juan Basin and the Navajo Indian Irrigation Project, both in New Mexico, will be presented.

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REMOTE SENSING SAMPLING METHODS FOR ETHNOGRAPHIC AND ETHNOHISTORIC RESEARCH

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Ethnographic and ethnohistoric studies are an important aspect of scientific research in National Park Service areas. Such research is facilitated by the use of remote sensing, perhaps most notably by using sensor data in "area frame sampling." This is because such sampling makes possible much more rapid and comprehensive data collection, over much larger areas, than conventional techniques for anthropological field data collection.

A methodology is described which was developed and refined in a research project conducted in the San Juan Basin of northwestern New Mexico, in and near Chaco Canyon National Monument. Remote sensing techniques have been combined with more traditional ethnographic and ethnohistoric procedures to write a land use history of the region.

Specific project objectives were to comprehend Navajo land use from their point of view, to understand their own, historical, processes of land management, and to describe how such practices have changed through the impact of wider social and economic change. Stratification procedures permitted sample sites to be selected from several environmental zones. Within each sample site, aerial photography and Landsat imagery were used to record environmental and settlement information.

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ANALYSIS OF MAGNETIC SURVEYING DATA FROM ARCHAEOLOGICAL SITES AT NINETY SIX N.H.S., SOUTH CAROLINA

WEYMOUTH, JOHN W.

We have been analyzing magnetic surveying data obtained by the Midwest Archaeological Center from a number of archaeological sites in national parks. Such data are produced by measuring the magnetic field of the earth on a grid of points above the surface of the site. Differences in subsurface soil magnetization produce local anomalies in the measured field. This paper will discuss examples of problems arising in such an analysis and some of the results obtained from surveys on several sites at Ninety Six National Historic Site in South Carolina.

Approximately 5 hectares were surveyed over historical and prehistorical sites in the park. The sites included colonial village Ninety Six destroyed during the Revolutionary War, Cambridge Village which then grew up and finally disappeared, an aboriginal area and an early colonial trading post.

The sites were marked by highly magnetic soils and gross geological trends. Use of mathematical filtering methods combined with detailed analysis of profiles and various types of magnetic maps aided in the interpretation and correlation with known archaeological information. One of the most interesting results was a long linear feature in the Cambridge Village area that appears to be caused by a filled road bed or ditch about 150 m long for which there is no surface indications.

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REMOTE SENSING: ITS USE IN THE CULTURAL RESOURCE RECONNAISSANCE PROGRAM OF THE BIG CYPRESS NATIONAL PRESERVE, FLORIDA

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The Big Cypress National Preserve in South Florida is located within the Big Cypress watershed and encompasses approximately 900 square miles of slough, marshes, hammocks and prairies. The region is generally less than 10 feet above sea level. Natural drainage is by slow overland sheet flow to the south and well-defined streams do not exist except along the coast. The size and natural environment of the preserve has posed special logistical, surveying, and recording problems which have best been solved using false color aerial infrared photography.

Site signatures have been determined and predictive models generated for site locations. Additional Remote Sensing techniques have been used to determine the accurate location of intermediate and abandoned water courses used in the past by Seminole and prehistoric peoples as inland waterways.

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A PRACTICAL APPLICATION OF REMOTE SENSOR METHODOLOGIES UTILIZED DURING THE CULTURAL RESOURCE INVENTORY OF NINETY SIX NATIONAL HISTORIC SITE, SOUTH CAROLINA

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The National Park Service, Southeast Archeological Center in Tallahassee, Florida utilized the results of two remote sensor analyses of Ninety Six National Historic Site to facilitate a cultural resource inventory. These two techniques included a proton magnetometer survey conducted by the National Park Service, Midwest Archeological Center and photo interpretation and photogrammetric mapping by the National Park Service, Chaco Center, Remote Sensing Division. The data provided by these non-traditional and non-destructive archeological techniques continues to provide information to park management for planning and development requirements. The results of the proton magnetometer investigations have most recently been utilized to relocate the original streets of the past Revolutionary War village of Cambridge so that a subsurface waterline can be lain without undue disturbance to this National Register site. The magnetic survey which was conducted just south of the proposed construction site located an area of magnetic high values which apparently correspond to one of the Cambridge streets. This is approximately 100 feet east of South Carolina highway 248 which runs north/south in front of Ninety Six National Historic Site. By coordinating this set of magnetic highs and existing landmarks with landmarks indicated on a 1783 plat of Cambridge, the location of one of the historic "streets" was obtained. By projecting this "street" northward to the desired construction site, unnecessary damage to the individual village lots was avoided by placing the waterline within this corridor. The street location was verified archeologically and pipeline installation was monitored. Data was also provided to the Park on the location and configuration of the village lots as well as the probable extent and location of the village boundaries.

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AN OVERVIEW OF THE ARCHEOLOGICAL RESEARCH PROGRAM AT KNIFE RIVER INDIAN VILLAGES NATIONAL HISTORIC SITE

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The Knife River Indian Villages National Historic Site was established by Public Law on October 26, 1974, with the intent to preserve the villages and define and interpret Hidatsa lifeways. The Midwest Archeological Center has developed a research program designed to resolve questions concerning the origins of the Hidatsa, relationships of the Hidatsa and the Mandan, and provide the data necessary for interpretation preservation, and management of the area.

The initiation of the program at Knife River Indian Villages began with the resolution of staffing and funding problems and the development of a formal research/management plan. The Center has established an agreement with the University of North Dakota and other institutions to conduct various portions of the research work. A major objective of the program is to learn as much about the villages as possible by employing nondestructive archeological techniques. Aerial photography was used to map the park and villages at a scale sufficient to allow onsite identification of specific archeological features. Magnetic survey techniques were used to provide subsurface maps of the village areas and a program to field test a sample of these features was initiated. Studies were initiated to evaluate the potential for archeomagnetic and thermoluminescent dating. Ethnohistorical, historical, and historical cartographic data for the Knife River area are also being collected.

In summary, the program was established to evaluate the resources at Knife River Indian Villages using nondestructive archeological techniques while exploring other potential approaches to resolution of research and management problems. The preliminary results of research to date will be discussed.

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ARCHEOLOGICAL RECONNAISSANCE AND TEST EXCAVATION IN THE KNIFE RIVER INDIAN VILLAGES NATIONAL HISTORIC SITE, NORTH DAKOTA

AHLER, STANLEY A. and WESTON, TIMOTHY

The cultural resources inventory of the Knife River Indian Villages National Historic Site (KNRI) has faced the unusual problem of a nearly continuous scatter of artifactual materials throughout major parts of the Historic Site area. Surface reconnaissance in the KNRI has centered around the use of the point-quarter survey technique which was adapted from its original biological use to application in the archeological situation. Using this sampling procedure, surface artifact density data have been computed for an area of more than 100 HA in the southern part of the KNRI where most developmental and interpretative programs are likely to occur. Maps of surface artifact density have been produced using the SYMAP computer graphics routine, and such maps have allowed precise spatial definition of at least 16 new archeological sites and several non-site zones in the surveyed area. The point-quarter reconnaissance has proven to be a valuable planning tool for both archeological research and management needs.

Since 1976 test excavations have been conducted in six major archeological sites in the KNRI. The purpose of the testing has been to investigate site stratigraphy and content, collect samples for chronometric dating, investigate magnetic anomalies, and, in general, to develop baseline data for future excavation and interpretative programs. Investigations reveal a continuum of Plains Village Tradition occupation from the mid-16th century through the mid-19th century. During this period, village sites changed markedly in structure and plan from broadly scattered hamlets containing (presumably) rectangular dwellings to tightly agglomerated, fortified villages of circular earth covered dwellings. Ceramics and other aspects of material culture change markedly during this period, as well, apparently reflecting the combined effects of introduction of Euro-American technological items and decimation of Native American populations by two or more major smallpox epidemics.

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DESIGNING A MAGNETIC SURVEY

NICKEL, ROBERT

Large scale magnetic surveys require several compromises in order to be efficient and yet remain responsive to archeological project goals. An archeologist must decide on the type and sensitivity of the instruments, whether to use a gradient or differential mode, choose between traversing or using a grid system and select the most meaningful method of data analysis. Each of these matters entails tradeoffs between time, cost and the size of the magnetic anomaly which can be resolved. The Midwest Archeological Center has developed a package of equipment which is suitable for most applications. The results of recent surveys at Knife River Indian Villages are reviewed and the assets and liabilities of our system are evaluated. Some general guidelines for other Service archeologists to use in planning and evaluating magnetic surveys are presented.

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QUATERNARY GEOLOGY OF THE KNIFE RIVER INDIAN VILLAGES NATIONAL HISTORIC SITE

REITEN, JON

A geologic field study of the Quaternary sediments of the Knife River Indian Villages National Historic Site and surrounding area was conducted during the summers of 1978 and 1979. The research concentrated on alluvial deposits and physiographic features representing variations in the activity of the Knife and Missouri Rivers. In the study area past events of valley floor aggradation and terrace cutting control the present topography.

Four Pleistocene paired terraces have been identified at the following elevations above present river level: 10-15 meters, 20-25 meters, 30-36 meters, and 50-60 meters. These terraces probably are the result of fluctuating river levels during the numerous glaciations which have occurred in the region.

Three Holocene terraces have been identified along the Knife River at elevations above river level of: 0-4 meters - present floodplain, 5-6 meters, and 7-8 meters. Results of C-14 dating on charcoal collected within these terraces have not been received but should help determine times of river aggradation and times of trenching. The Holocene terraces along the Knife River are probably the result of climatic changes. The changes are probably nearly synchronous with climatic variations which have been demonstrated to have influenced soil formation, slope stability, loess deposition, and sedimentation in sloughs of central North Dakota. The Missouri River apparently has not been affected significantly by Holocene climatic variations since no Holocene terraces other than the modern floodplain are present.

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THE JOHN EVANS 1796-1797 MAP OF THE MISSOURI RIVER

WOOD, W. RAYMOND

The first map of the upper Missouri River which represents direct observation of the area (following those resulting from the explorations of the La Vérendryes in the mid-18th century) is one by John Evans, who, under the direction of James Mackay, explored the Missouri River between 1795 and 1797. John Evans' map of his exploration of the upper Missouri River is the earliest eye-witness map of the area now incorporated in the Knife River Indian Villages National Historic Site. A copy of this map, the original of which was made in 1796-1797, was sent to Meriwether Lewis by President Jefferson, and appears to have been obtained from William Henry Harrison. It has been preserved among the documents of the Lewis and Clark expedition.

This map is a crucial one for understanding the pre-Lewis and Clark geographical knowledge of the vicinity of the mouth of the Knife River, but it must be used with caution. A significant part of the legends on Sheet 6 of this map (which shows the mouth of the Knife River and the Knife River Indian Villages) has been added by individuals other than the original draughtsman of the map. There are several notations in Clark's hand, for instance, which are based on observations made during the 1804-1806 expedition, and one inscription that appears to be in the hand of James Mackay, apparently based on his experiences in Canada in 1787.

By deleting the Mackay and Clark annotations on the map, a reasonable approximation of the original map is obtained--a map which was an important source for Clark's own maps of the Missouri River.

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ETHNOHISTORICAL RESEARCH PERTAINING TO THE KNIFE RIVER INDIAN VILLAGES NATIONAL HISTORIC SITE

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The nature and status of an in-progress ethnohistorical study into the relationships of the Mandan and Hidatsa Indians with British and Canadian fur trading concerns are outlined, and some tentative results are presented.

Beginning in the last quarter of the eighteenth century, the Mandan and Hidatsa Indian villages at the confluence of the Knife and Missouri Rivers in central North Dakota increasingly attracted the attention of British and Canadian fur trading interests. This economic interest in the villages took two forms: 1) individual (and largely independent) traders who permanently resided in the villages and 2) trading expeditions sent by organized British and Canadian fur trading companies from posts along the Assiniboine River and its tributaries in southern Manitoba. The latter form of trade persisted into the first decade of the nineteenth century, when American sovereignty was proclaimed in the area.

The Mandan-Hidatsa trade during this period has not been the subject of in-depth historical or ethnohistorical studies, although several first-hand accounts of the trade have been made available by a number of editors. With certain exceptions, most of these accounts have been published in abridged or otherwise highly edited form, limiting their usefulness for contemporary research.

These primary accounts, as well as data from an important unpublished series of annual journals which detail the extent of Hudson's Bay Company activities at these villages, are being re-examined and re-analyzed at the University of Missouri and the Midwest Archeological Center. Viewed together, these sources contain a wealth of information on the frequency of trading expeditions to the villages, the techniques employed in the trade, the nature and relative importance of products being obtained in the villages, and the intensity of competition between the trading companies. They will also provide the basis for a reassessment of the extent to which the Mandan and Hidatsa Indians had been acculturated by these frequent contacts with Euro-American culture prior to the arrival of Lewis and Clark in 1804. The results of the study will be useful for the interpretive program at the Knife River Indian Villages National Historic Site.

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AN ETHNOHISTORICAL INTERPRETATION OF THE SPREAD OF SMALLPOX IN THE NORTHERN PLAINS UTILIZING CONCEPTS OF DISEASE ECOLOGY

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The spread of smallpox in 1837 among the aboriginal population at Fort Clark, in what is now North Dakota, is examined within the framework of a disease ecology model. This model comprehends biological variables, viewing health and disease as expressions of dynamic relationships between populations, their cultures, and their environments. The smallpox epidemic at Fort Clark in 1837 destroyed the Mandan as a tribe and culturally shattered the Hidatsa and Arikara as well. It is postulated that the epidemic was introduced to the native populations by three Arikara women who disembarked at Fort Clark from the supply steamboat St. Peter's. The cultural, biological, and environmental variables at Fort Clark combined with the disease to produce a devastating epidemic. The results were that thousands died, tribal cultures and social organizations were disrupted, altered, or virtually obliterated. The tribal balance of power within this area underwent drastic realignment and, with the reduction in population, the fur trade began to decline. Thus the smallpox epidemic of 1837 forever altered the aboriginal composition of the Upper Missouri region.

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MAGNETOMETER SURVEY OF VIRGINIUS ISLAND, HARPERS FERRY NATIONAL HISTORICAL PARK

CARPENTER, SCOTT L.

Numerous industrial and domestic structures were situated on Virginius Island, in the Shenandoah River, during the nineteenth century. Successive flooding eventually led to the devestation of the area. As part of the development of Harpers Ferry National Historical Park, an archeological investigation and ruins stabilization program is being conducted on Virginius Island. Included in the investigation is the utilization of proton magnetometer survey for the purposes of (1) locating subsurface remains of foundations and other archeological features, (2) assessing the feasibility of the survey and analysis procedures for utilization with future projects with similar geographical and archeological elements. This paper discusses the rational and methodology of the survey and the interpretive analysis of the resultant data. Magnetic anomolies are analyzed with supporting information obtained from historic maps as well as from surface and subsurface archeological investigations in order to establish a key for interpreting magnetic survey results from localities lacking archeological documentary information.

HISTORIC SITE ARCHEOLOGY AT FORT CHARLOTTE, GRAND PORTAGE NATIONAL MONUMENT, MINNESOTA

JONES, BRUCE A.

Grand Portage National Monument contains a wealth of archeological resources which help to document the history of the fur trade in the United States and Canada. Scientific investigation of these remains has largely occurred at the eastern end of the portage. However, recent archeological research at the western terminus, generally known as Fort Charlotte, suggests that as many as four separate fur trade establishments may have flourished there which may provide substantive archeological evidence relating to the history of European/Indian relations in North America.

Intensive National Park Service involvement in the archeological resources of the Fort Charlotte area did not begin until 1978. Prior to that time, staff of the Minnesota Historical Society had mapped a complex system of shallow furrows and rock concentrations at the mouth of Snow Creek which were suggestive of structural remains, and had also conducted underwater archeological excavations in the Pigeon River off Fort Charlotte, where historic artifacts dating as early as the mid-17th century were recovered. However, the surface features remained problematical, their nature and extent incompletely understood, and they presented major concerns to the Park both in terms of historical interpretation and in terms of resource management and the nondestructive use of the area by visitors.

The 1978 and 1979 NPS field seasons in the Fort Charlotte area constituted the first stages of a multifaceted program designed to provide solutions to several of these problems. In 1978 proton magnetometers were used by personnel from the Midwest Archeological Center to identify subsurface archeological features across 900 m^2 in the areas of the presumed North West Company and XY Company posts. These investigations were purposefully conducted in locations where extant surface remains were previously believed to represent fireplaces and wall or palisade trenches. The results of the work indicated the presence of several large magnetic anomalies and generally seemed to support the traditional interpretation of the surface features.

As a control for the 1978 work, the 1979 MWAC investigations continued the use of the magnetometers, this time in locations adjacent to but not containing visible surface features, and further evidence of subsurface remains was obtained. Additionally, because Park personnel were concerned that visitor campground facilities at Fort Charlotte be relocated away from the archeological resources, a systematic series of subsurface tests were excavated, both to determine the limits of the historic remains as well as to identify any previously unidentified archeological resources.

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ARCHEOLOGICAL INVESTIGATIONS AT VOYAGEURS NATIONAL PARK, MINNESOTA

LYNOTT, MARK J.

Prior to the 1979 investigations, archeological research at Voyageurs National Park concentrated on locating archeological sites through shoreline survey. Enlargement of lakes along the Rainy River through dam construction early in this century, has created a potentially adverse impact on the archeological resource base. The 1979 investigations were designed to consider the management implications of this situation, and to shed light on the nature of prehistoric adaptation in the region.

Through the use of survey transects and site testing, data relating to various aspects of prehistoric adaptation have been collected. This paper provides a preliminary report of the 1979 investigations, and offers an interpretive model of late prehistoric exploitation of the region.

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ARCHEOLOGICAL INVESTIGATIONS AT APOSTLE ISLANDS NATIONAL LAKESHORE, WISCONSIN

RICHNER, JEFFREY J.

Midwest Archeological Center fieldwork at Apostle Islands National Lakeshore in 1979 focused upon evaluating the condition of several prehistoric sites as well as surveying various proposed development areas. Limited site testing was undertaken at sites on five islands to determine the effect of shoreline erosion on the sites. Site survey was conducted within several areas, including proposed trail and campground projects. The archeological project was part of ongoing multidisciplinary studies of past and present cultural and natural environments at the National Lakeshore. One aspect of the study included paleoecological analyses of pollen and charcoal from sphagnum bogs and archeological sites spanning the last 10,000 years. Archeological evaluation of the effects of erosion at certain sites was aided by information gathered by other researchers focusing on shoreline processes. As a result of the project, new information regarding past ecological settings at the archipelago was obtained and numerous historic and prehistoric sites were evaluated in regard to their local and regional significance.

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ARCHEOLOGICAL SURVEY OF CAPE COD NATIONAL SEASHORE - 1979

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In May, 1979, an archeological survey of Cape Cod National Seashore was begun. The survey aims to provide information on historic and prehistoric archeological sites. The information is needed for effective management and interpretation of these resources. Specific goals include: the discovery of a sample of sites; the use of site information to estimate the number of sites in the Seashore; the prediction of likely site locations based on the sample; and the interpretation and assessment of sites discovered and expected to exist within the Seashore.

The first year's efforts concentrated upon site discovery. The Seashore was sampled using both probabilistic and non-probabilistic selection of sample units. Discovery techniques used included surface inspection, soil cores, bucket augers and shovel test pits. Various test intervals were used and tested also.

The survey's results will be used to plan the next year's efforts. The examination of some sites for interpretation and assessment and refinement of site frequency and location estimates are the goals of the second year.

ON THE RELATIONSHIP BETWEEN MESA VERDE STYLE ARCHITECTURE AND FREMONT STYLE ROCK ART

ANDERSON, ADRIENNE B.

In 1962 Floyd Sharrock noted, based on his archeological survey work in Canyonlands National Park and vicinity, an apparent incongruous relationship between the Fremont Culture rock art and the Mesa Verde Anasazi Culture architecture and ceramic types prevalent in the canyonlands country. He first pointed out, and subsequent researchers supported, the enigmatic occurrence of Fremont style rock art at what otherwise appeared to be unquestionably Mesa Verde Ansaszi sites. Fremont and Anasazi were considered two distinct, generally mutually exclusive cultural groups. However, somewhat after Sharrock's study, Polly Schaafsma in 1971 defined three basic rock art styles that occur in the canyonlands country: Pueblo period Anasazi, Pueblo period Fremont, and Archaic period Barrier Canyon. Prior to this stylistic differentiation Barrier Canyon and Fremont art had been lumped together; all were considered Fremont.

Ongoing work in the canyonlands area suggests it is the Archaic period Barrier Canyon style rock art panels that occur at Mesa Verde Anasazi structural sites, while the Fremont style art panels occur either in isolated situations or at sites that can not be clearly identified as either Anasazi or Fremont. Discussion of this problem centers around several points that have yet to be resolved: (1) Acceptable definition of a Fremont Culture and distinction of Fremont sites. (2) Authentication that Fremont style rock art is, in fact, a product of a distinct Fremont Cultural group. (3) Field verification of a significant sample of the occurrence of Barrier Canyon style rock art at Mesa Verde Anasazi sites. (4) Field verification of the nonoccurrence of Fremont style rock art at unquestionably Mesa Verde Anasazi sites.

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PALYNOLOGICAL INVESTIGATIONS AT CURECANTI NATIONAL RECREATION AREA, COLORADO

SCOTT, LINDA J.

Pollen analysis conducted at several archaeological sites in the Curecanti National Recreation Area in Colorado was oriented toward examination of the past environment. Indications of exploitation of the environment by the prehistoric residents of the area were also sought. The sites examined for palynological evidence vary from isolated firepits, the remnants of a burnt wickiup-like structure or "house", and a possible unburned "house", to a cave with a possible human occupation. Radio carbon dates from the open sites range from 4300 BP to 9800 BP. Although no dates are available from the cave, Pleistocene horse remains were noted at a depth of 80 to 100 cm below present ground surface.

The environmental data sought were concerned with identification of changes in the local environment through the time of the dated occupation of the area, which appears to end at the close of the Altithermal. Availability of food resources in the area, particularly pinon pine, was deemed important, and fluctuations in the level of small pine pollen (probably representative of pinon pine) have been traced in the pollen record. The absence of pinon pine from the present flora of the Curecanti Basin is somewhat of an enigma, since the environment should presently support pinon. The presence of burned pinon nut remains in a hearth and the absence of pinon pine from the local environment lead to a detailed investigation of the prehistoric environment of the Curecanti area to determine whether or not pinon pine was present in the Curecanti Basin between 9800 BP and 4300 BP, or whether the occupants of these sites had to travel outside the basin to gather pinon nuts.

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ALTITHERMAL ADAPTATIONS IN CURECANTI NATIONAL RECREATION AREA

STIGER, MARK A.

Archeological research in Curecanti National Recreation Area, western Colorado, has revealed prehistoric occupation of the area dating from 10,000 B.P. to 4,000 B.P. Excavations have produced architecture similar to the historic Numic wickiup. Charred piñon nuts indicate some dependence upon this ethnographically important food source. Floral and faunal remains indicate several other economically important species were present during the altithermal but are now extinct in the upper Curecanti basin. These species are present in surrounding areas of similar environmental conditions today. It is posited that environmental fluctuations at the end of the altithermal and the closed basin topography of the upper basin resulted in the extinction of several species within the upper Curecanti basin. As conditions ameliorated, the closed basin topography precluded the return of these species to the upper Curecanti basin. The sparse to absent post-altithermal occupation in the upper Curecanti basin may be linked to the environmental fluctuations and availability of floral remains.

Field work during the summer of 1979 is concentrating on tightening the occupational chronology and obtaining data to test the above described relationship between environmental and occupational patterns.

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ENVIRONMENTAL CHANGE AND CULTURAL VARIATION: THE VIEW FROM THE HIGH COUNTRY OF NORTHWESTERN WYOMING

WRIGHT, GARY A.

The relationship between cultural change and alterations in the natural environment has been an intensely argued issue in the anthropological literature. This essay discusses this problem from the perspective of archeological research conducted in Grand Teton and Yellowstone National Parks, Wyoming, over the past eight years. We begin with a single assumption: cultures are, first of all, symbolic systems. Hence, for any cultural system, both the environment under exploitation and the mode of production are symbolically determined. It is thus argued that before hypotheses about cultural change can be tested against parameters of environmental change, the investigator must reconstruct the specific habitats under exploitation rather than some vague total environment. Environmental shifts over time may then be analyzed in light of their affects on resource procurement.

Utilizing the data from northwestern Wyoming, it is shown that significant temporal variations in cultural content are uncorrelated with climatic change, and different types of explanations must be sought. By the Altithermal, a high country adaptive system had been established, and we see no important cultural variation until about A.D. 1600. This exploitive system was maintained despite clear shifts in treelines, mountain glaciers, and other indicators of climatic change. It is argued that the symbolically meaningful resources and their habitats were unaffected by these climatic changes. Subsequent post-A.D. 1600 cultural changes were due to factors such as population movements of new ethnic groups into the region and the later diffusion of horses and guns from Euro-American areas which resulted in the evolution of the Plains horse-nomad adaptation.

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EXCAVATIONS AT SHEEPEATER BRIDGE, A FISHING CAMP, YELLOWSTONE NATIONAL PARK, WYOMING

MARCEAU, THOMAS E.

The Sheepeater Bridge site, 48YE320, is located on the middle terrace of a set of three on the east side of the Gardner River, Yellowstone National Park, Wyoming. Archaeological investigations were conducted during June and July of 1977. A grid of five by five meter squares was established to serve as standard for collecting. A total of 6,871 artifacts were recovered; 4,907 from the surface collection of 195 squares and 1,964 excavated from 15 one meter test units. Obsidian accounted for 97% of all lithics obtained. Hydration analysis demonstrated at least a 7,000 year period of site visitation. Dates ranged from 7,100 to 382 B.P.. Early lanceolate, McKean, and Plains side-notched points are represented in the surface collection. Analysis of the total assemblage focused on describing three aspects that might cumulatively indicate a range of activities undertaken at the site. Tool industries were described on the basis of stone materials brought to the site, the formal characteristics of stone-knapping or manufacture, and the hypothesized functional characteristics of tools used. Emphasis is given to the network of manufacture and use of small blade and flake tools. Most of these tools are broken, with heavily worn edges. Scars on broken surfaces suggest re-use of available stone at later times. In all, six tool types are defined: notches, perforators, straight blades, convex blades, straight flakes, and convex flakes. Springtime fishing as a major economic activity at 48YE320 is indicated through consideration of aspects of the local ecology, availability of riverside and aquatic resources, and by the tools. Artifact clusterings suggest various stages in the production of fishing gear.

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ETHNOBOTANICAL MODELS AND ARCHEOLOGY IN GRAND TETON AND YELLOWSTONE NATIONAL PARKS

REEVE, STUART A.

Archeological research in Yellowstone and Grand Teton National Parks has emphasized the development of comprehensive ecological models, relevant to interpreting a broad range of prehistoric settlement types; from large multi band base camps to specialized small group work areas. Plant resources appear to be particularly important in scheduling migratory cycles and structuring band territories. A number of procurement strategies are evaluated by projecting the species-use of Native American peoples from the Rocky Mountains and surrounding regions to the plant communities of the study area. Both the adaptive patterns of particular tribal groups as well as the total resource availability of local environments can be evaluated in terms of the archeological record. Further problems of Holocene environmental change are also approached by integrating palynological, biogeographical and geological models. The archeological record thus emerges as an independent and critical body of data for testing diverse hypotheses concerning cultural and environmental change.

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PREINUNDATION SURVEY AND EXCAVATIONS IN GLEN CANYON NATIONAL RECREATION AREA, UTAH

TIPPS, BETSY L.

Recent archeological investigations in Glen Canyon National Recreation Area, southeastern Utah, have concentrated on preinundation survey and excavations, evaluation of visitor impact upon archeological resources, and the determination of stabilization and interpretive needs. While management and protection of archeological resources is the motivating force for this work, the information gathered is also pertinent to the formulation and resolution of archeological problems.

In an attempt to evaluate patterns of stability and change in the prehistoric settlement-subsistence system in Glen Canyon, archeological investigations have focused on the examination of traditional environmental and cultural variables as well as those that have often been neglected in past research. Intensive surveys in upland areas and upstream portions of side canyons on the Colorado River as well as the better known mouths of side canyons and mainstem of the Colorado was made. Emphasis was placed upon evaluating the small sites and non-residential units which have the potential to yield information that is different from, but equally important to the cliff dwellings and pueblo sites in understanding regional prehistoric adaptation.

Recent field research has revealed numerous lithic sites, a quarry area, grinding and tool sharpening sites and scattered chipping stations, all in areas previously believed to be devoid of archeological resources. Newly discovered cliff dwellings and masonry structures were found in traditional places, in alcoves and under overhangs. These recent data, especially those pertaining to non-habitation sites in marginal upland settings, are being evaluated in conjunction with existing information on the prehistoric period in Glen Canyon. While some of the early ideas about prehistoric use of the area are supported, new questions are certainly raised. Some of the newly defined problems are examined. Tentative hypotheses and formulated interpretations, in light of recently collected information, are examined in this report.

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THE FORT MASON SITES: PREHISTORIC ARCHAEOLOGY IN AN URBAN ENVIRONMENT

BAKER, SUZANNE

As part of extensive re-landscaping at Fort Mason, Golden Gate National Recreation Area, San Francisco, California, the National Park Service requested a systematic augering program for prehistoric and historic resources. As a consequence three aboriginal sites with large quantitites of undisturbed midden have been found at Fort Mason. Test excavations have shown that they are of great importance to the prehistory of the northern San Francisco peninsula. Of six known extant sites in San Francisco, only these three have intact midden. Since these sites were found under large areas of concrete foundations and asphalt, the work also shows that the potential remains for the existence of other aboriginal sites in highly urbanized environments. Urban planners should be encouraged to consider this fact in environmental impact assessments.

Dense shell midden was found in two of the sites, SFr-29 and SFr-30. They appear to have been at least semi-permanent habitation sites. Over 120 aboriginal artifacts were found in four test units, including approximately 30 bone beads and awls, obsidian tools and flakes from Annadel and Napa Glass Mountain, whole shell olivella beads and haliotis ornaments, a net sinker, grooved baked clay, a large quartz crystal, ground stone fragments, ochre, and a carefully pecked and faceted stone, the function of which is unknown. Features included several hearths, shell concentrations, and a large pile of fire-cracked rock, possibly a cooking stone cache.

SFr-31, the third site, in the two test units excavated had much less shell, but very black midden with considerable quantities of fire-cracked rock and fish bone, very burned sand, hearth, two net sinkers, and obsidian and quartz tools. This was possibly a food processing area for an activity such as fish drying.

A large faunal collection was made, consisting of sea and land mammals, birds, fish, and shellfish. Both coastal and bay environments were being exploited. Macoma nasuta was the predominant shellfish. When analyzed the faunal collection will be of great importance not only for dietary and hunting information, but for reconstructing the prehistoric ecology of the northern San Francisco peninsula.

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THE ARCHAEOLOGY OF THE NORTH RIM OF GRAND CANYON

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Recent archaeological surveys on the North Rim of Grand Canyon have yielded data that enable us to revise and enlarge upon our previous knowledge of the prehistory of that area. This paper discusses:

1) Settlements on the North Rim were confined to pinyon-juniper and ponderosa pine vegetation. The southern boundary of the latter, however, has shifted south in recent years and archaeological sites may occur in the higher fir-aspen zone.

2) The geographic focus of the Anasazi, the dominant prehistoric group on the North rim, was to the inner canyon. Where routes of access between canyon and rim exist, sites are located overlooking these routes; elsewhere, sites are scarce.

3) A transect of a portion of the Walhalla Plateau permits an estimate of 123 rooms per square mile on the ridgetops in Pueblo II. Even outlying areas, such as Powell Plateau where there is no water, contain 33 sites per square mile.

4) Water sources available to the prehistoric inhabitants included snow banks, spring runoff, natural sinks, and springs below the rim. Agricultural terrace systems would have collected spring moisture.

5) Earliest Anasazi occupation began ca. A.D. 800, not A.D. 1 as has been previously suggested.

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ARCHAEOLOGICAL RESEARCH ON CALIFORNIA'S CHANNEL ISLANDS

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Recent field work on three islands off the California coast-Anacapa, Santa Barbara, and San Miguel-has provided an inventory and assessment of historic and prehistoric cultural resources, many new insights into the preservation and management of archaeological sites, and a fuller evaluation of the potential contained in these islands for interdisciplinary research. There are now 18 sites recorded on Santa Barbara Island, 26 on Anacapa Island, and 548 on San Miguel.

The islands contain rare, endemic, and endangered species of plants, birds, land mammals, and sea mammals in addition to the cultural resources, and all are to varying degrees threatened by certain adverse impacts not routinely encountered in mainland environmental studies. It also happens that the gathering of data by one scientific discipline actually diminishes or destroys the data base of another.

New laws and guidelines have affected the evaluation of cultural resources. For example, the Lester ranch house complex on San Miguel Island was assessed in 1965 as merely a "hand-built oddity" not worthy of preservation, and it burned in 1967. Under current standards of significance, it is considered eligible for the National Register of Historic Places, as an archaeological site even though the architecture has been lost.

New directions for prehistoric research arise from the growing realization that aboriginal occupation of these islands is much more complex and very much older than early studies indicated. Radiocarbon dates on San Miguel Island from Johnson's geomorphological research extend back to 7940 BP on midden shell, to 9750 BP on charcoal which may be related to human occupation, and to 16,500 BP on charcoal in direct association with burned/calcined mammoth bone. The simple assumption that these islands were utilized sporadically by the Chumash in the late protohistoric and early historic periods is no longer tenable on the basis of these dates, the high site density of 15 per sq. km., the size, depth, and complexity of the sites, and the great number of burials.

The challenge to NPS management is perhaps the greatest on San Miguel where a truly integrated interdisciplinary approach would both maximize the data potential for all of the sciences, and at the same time conserve the data base by extracting the most information from the least number of investigations.

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CHEMICAL STABILIZATION METHODS FOR PREHISTORIC STRUCTURES AT CHACO CANYON NATIONAL MONUMENT

FENN, DENNIS B.*, DECK, JOHN R.**, AND HERRIMAN, WALTER P.***

Controlled studies were initiated in Chaco Canyon National Monument in July, 1975 to evaluate the potential effectiveness of chemical products in protecting prehistoric structures from the erosive forces of rainfall, ground moisture and wind. A total of 35 chemical waterproofing products have been field tested in Chaco Canyon to date in this study.

Tests have been performed on these products as stone preservatives, mortar amendments and pithouse wall preservatives. Results thus far show that spray treatments for stone and pithouse wall preservation are ineffective and perhaps even harmful to the resource. Several products however, are showing good erosion resistance when used as mortar amendments. These promising products are all water based emulsions and make repointing mortars that are nontoxic and easy for the stabilization crew to apply.

A complete laboratory analysis, including unconfined compressive strength, wet strength and water absorption properties has been performed on standard mortars made with each chemical product tested. The laboratory tests results correlate well with the field test results.

Monitoring of the field test plots will continue for an additional five years to provide a complete and thorough analysis of this proposed method of ruins maintenance.

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EFFECTIVENESS OF POLYMERS IN CONTROLLING MUD PLASTER EROSION AT BENT'S OLD FORT NATIONAL HISTORIC SITE

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This study was initiated at Bent's Old Fort in May, 1977 to evaluate the effectiveness of selected polymers in rendering mud plaster resistant to water and wind erosion. Thirty-five products have been tested thus far in 3' by 6' plots on the west-facing exterior wall of the corral at the rear of the reconstructed fort.

Driving rains and high winds, sometimes preceded by long gentle showers that can soak an adobe wall, characterize the climate of the southcentral Colorado plains. Two years of exposure to this weather has provided a severe test for the polymer-amended plasters in this study. Eight products used to make amended plaster and nine products sprayed onto unamended plaster panels are showing outstanding erosion resistance after 24 months exposure. The remaining 18 products tested failed to resist erosion to a satisfactory degree.

Research indicates that a polymer concentration of at least 10% solids in the solution used to mix the plaster or spray on the wall is necessary to produce satisfactory erosion resistance.

Monitoring of the test panels at Bent's Old Fort will continue for at least two more years in order to provide a complete evaluation of this promising maintenance procedure.

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STANDARD METHODS OF ANALYSIS FOR RUINS MAINTENANCE MATERIALS

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The sucess or failure of a ruins preservation effort is often determined by the initial choice of materials, i.e., soil, water, stone, cement, etc., to be used in the project. Work conducted in the Materials Laboratory at the Western Archeological Center since 1976 has demostrated that it is adviseable to have a series of standard analysis performed on the key materials to be used in a stabilization project before initiating the actual field work.

This paper describes the standard tests recommended for use in determining the mechanical suitability of soils, stone, and soil-cement for use in ruins preservation. Tests such as particle size distribution, x-ray diffraction, consistency limits, salinity, unconfined compressive strength, and capillarity are discussed and recommendations made as to suitability criteria.

The intended use of the material, i.e., replacement stone, soil-cement, repointing mortar, mud plaster, etc., and the climatic conditions prevelent at the site influence the suitability criteria.

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LOCATING SOIL MATERIAL FOR USE IN ADOBE STABILIZATION AT FORT BOWIE NATIONAL HISTORIC SITE

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Preservation of adobe or earthen structures is a continuing problem. Various chemical amendments have been tried in the past, but they were often ineffective. A project at Fort Bowie was initiated to locate source areas of suitable soil that could be used successfully as unamended mud mortar or plaster material.

The senior author conducted a field analyses and prepared a soil map of the site, specifically identifying areas that had the greatest potential for use in the stabilization project. Samples were collected and laboratory analysis completed. This information was then used for comparative purposes with data available on the historic adobe material.

Three distinct adobe soils were used in the construction of Fort Bowie. These adobe materials were: a light gray, clay loam material; a reddish-yellowish brown sandy clay loam or sandy loam; and a grayish-brown sandy clay loam or sandy loam. Extensive field notes and observations plus laboratory analyses characterizing the particle size distribution, types of clay minerals, soluble salts, and various porosity-compression strength measurements were made.

The soil map showed that only limited source areas exist for two of the historic adobe materials, whereas the grayish-brown soil is widely distributed within the monument. Results using these identified soil sources for the stabilization project currently underway at Fort Bowie have been encouraging.

A secondary benefit gained from this study was the verification of the borrow pit locations for soil materials used in the original fort construction.

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PRESERVATION OF ROCK ART AND ADOBE STRUCTURES

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The preservation of rock art and sandstone and adobe structures of archeological significance continues to receive increasing attention as an important approach to maintaining and understanding our cultural heritage. While the desirability of preserving such artifacts has been widely recognized, relatively little exploratory research is underway considering the magnitude of the problem. This paper is concerned with the utilization of methyl methacrylate as an approach to an effective and practical preservation procedure.

In earlier work in this laboratory the placement of sandstone in a shallow layer of methyl methacrylate containing benzoyl peroxide for two days at 32°C was found to result in a dramatic improvement in cohesive strength and water resistance. This clearly demonstrated the inherent potential of in situ polymerization and led to studies designed to make the process suitable for field application.

Repeated application of methyl methacrylate solutions containing benzoyl peroxide to sandstone at 25 to 30°C by a spray technique led to very little in situ polymerization. While improved results were obtained with treating solutions at 60°C, this procedure presents difficulties in field application.

In a search for a more active initiator, it was found that 2,2-azobis(2,4-dimethyl-4-methoxyvaleronitrile) was effective in inducing the in situ polymerization of methyl methacrylate in the temperature range of 32 to 37°C when the solution was applied to the substrate as a wet spray adaptable to field application. Reaction variables such as temperature, solution viscosity, concentration of crosslinking agent and method of heating were found to play an important role in determining the nature and extent of the in situ polymerization.

Results obtained in the utilization of this procedure on a limited experimental basis in the field indicate the potential utility of the in situ polymerization of methyl methacrylate as a practical preservation technique.

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SOCIAL COMPLEXITY IN CHACO CANYON

SCHELBERG, JOHN D.

Previous investigators of the social complexity and organization of the prehistoric inhabitants of Chaco Canyon, New Mexico, have generally modeled their reconstructions after the Pueblo Indians of the ethnographic present. If strictly adhered to, such arguments of analogy provide a framework for archaeological interpretation which limits the testing of hypotheses concerning behavioral adaptations to various and varying environmental and social conditions and make questions concerning social organization unnecessary. The result has been a number of archaeological reconstructions which cannot be adequately tested in order to establish which may be closer to the actual sequence of events. The pre-occupation with arguments of analogy has resulted in a lack of consideration of the relationship of Chaco Canyon to its surrounding region. Likewise there has been no serious investigation into the possibility of a more complexly organized social system than that of the egalitarian Pueblo Indians of today.

It is suggested that the events which occurred in Chaco Canyon cannot be understood without understanding the ecological and social conditions of the San Juan Basin and that the Chacoan social organization had to have been at least at the level of a chiefdom in order to successfully cope with a stressed and unstable environment of low predictability. In order to begin to understand the range of variability of the Chacoan sites, their interrelationships and the social system complexity, the settlement system should be analyzed in such a manner that organizational differences can be established. By creating a hierarchy of centers we can begin to ascertain social system complexity because the size of any hierarchy is a measure of the complexity. To initially establish the relationship of site size and complexity the Chacoan settlement system will be analyzed from the perspective of the rank-size rule.

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A SUMMARY OF CHACOAN CULTURAL TRAITS

INGMANSON, JOHN EARL

Several recent studies have indicated that the large communities in Chaco Canyon were the source for a number of cultural traits that appeared during the eleventh century in the area of the Mesa Verde Branch of the Anasazi culture. The northern movement of Chacoan cultural traits may have included both a diffusion of traits and an intrusive settlement of individuals from the Chaco area into the communities of the Mesa Verde Branch.

These cultural traits from Chaco have been reported for Lowry Ruin and the Escalante Site. They also may be identified within Mesa Verde National Park.

In Mesa Verde, Chacoan influence would include artifacts such as pottery vessels which have been identified as trade ware. It would also include religious, ceremonial architecture, such as the use of specific features in large kivas. Most interesting of all, however, may be the possibility that certain secular rooms in both cliff dwellings and surface ruins show resemblance in lay-out or masonry style to Chacoan sites. Where dating is available at Mesa Verde, it is consistant with the hypothesis that cultural traits of Chacoan origin may be identified in the Mesa Verde cultural area in late Pueblo II and early Pueblo III times.

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A RE-EVALUATION OF PREHISTORIC WATER CONTROL AT MESA VERDE

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A study of the archeological evidence for prehistoric water control systems, including ditches and reservoirs, used by the inhabitants of the Mesa Verde has cast doubts on the correctness of the interpretations. In particular, a supposed ditch---Far View Ditch--- which runs for four miles down Chapin Mesa and which is supposed to have carried water to lower areas of the mesa does not appear to have been a ditch at all, and there is evidence to suggest an alternative explanation. A feature associated with the Far View Ditch is a large circular stone-lined depression which has been interpreted as a reservoir for water storage. Similar features have been recorded elsewhere in the Mesa Verde and one of these has been tested. Evidence uncovered in the tests as well as a study of the settings of these features suggests that the interpretation of their function may also be incorrect.

A review of the published literature on the Far View Ditch does not indicate any definitive evidence to support the conclusion that this was built for the purpose of channeling water down the mesa. Given its location on a narrow mesa with no permanent source of water other than seasonal run-off, the length and dimensions of the ditch make it seem to be a singularly impractical device since there probably would not have been sufficient run-off to fill it, and the absorption rate of the mesa soils would likely have prevented any water from ever reaching the end of the four-mile channel. A study has revealed a pattern of old steel axe cuts in the trees along the route, suggesting that the path of the ditch had been cleared in historic times. Early references by Fewkes and others to an old pack trail, which describe closely the route of the ditch, suggest that this may be the route taken down the mesa by early horseback groups visiting the ruins and by supply pack trains used before a road was built down the mesa. Thus the ditch could be the product of historic travel.

Doubts about the accuracy of interpretation of the Far View Ditch suggest that a reconsideration of the so-called reservoirs is also in order. Their efficacy as water storage devices is questionable, and their location on the mesa tops away from the natural drainage patterns requires that alternative explanations of their function be considered.

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NATIVE PLACENAMES IN EASTERN PRINCE WILLIAM SOUND, ALASKA

Ketz, James A.

In the early 1930s Kaj Birket-Smith (1953, The Chugach Eskimo) and Frederica de Laguna (1956, Chugach Prehistory) pioneered studies of the Chugach Eskimo, reporting many Native placenames from Prince William Sound, Alaska. Native typonomy, however, was an incidental aspect of their work and was not pursued systematically. Older, contemporary Native speakers remain a rich repository of Chugach Eskimo placename data that must be collected now if it is to be preserved. As an initial step in this direction and as a result of research in Prince William Sound pursuant to Section 14(h)(1) of the Alaska Native Claims Settlement Act (ANCSA) of 1971, this paper presents over one hundred Native names from Hinchinbrook and adjacent islands in eastern Prince William Sound on USGS maps of the region. This compilation follows a standardized orthography of the Chugach dialect of Alutiiq (the Chugach or Suk Eskimo language) developed by the Alaska Native Language Center at the University of Alaska, Fairbanks.

This paper discusses the importance of Alutiiq typonomy for general anthropological studies in Prince William Sound with specific reference to "historic" sites selected by Chugach Native regional corporation under provision of Section 14(h)(1) of ANCSA. It also emphasizes how placename data support the criteria of "significance," as outlined both in Section 14(h)(1) of ANCSA and the National Register of Historic Places.

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REINDEER HERDING AND TRADITIONAL SUBSISTENCE ON THE SEWARD PENINSULA

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The introduction of reindeer herding at the end of the nineteenth century makes the recent history of the Seward Peninsula particularly interesting.

Both historical archeology and local oral history reflect the changes that reindeer breeding brought to the area. For the past two summers, the ANCSA 14(h)(1) Project has been surveying, documenting and researching historic sites on the southeastern Seward Peninsula. This paper presents some of the results of our efforts, showing how these sites reflect the history of reindeer herding activities and their relationship to the traditional subsistence round.

Historic sites on the Seward Peninsula reflect three basic functions: coralling and herding, shelter for herders and hunters, and traditional subsistence activities. Frequently remains from more than one activity appear at any given site, and oral history accounts bear out the linkages between these activities.

During its early stages reindeer herds exhibited a variety of ownership patterns: individual mission, school and Reindeer Service. Emphasis shifted to individual herds until the 1930s when a variety of problems led to the formation of village or cooperative herds. More recent times have again seen a shift toward individual herds. These and other changes in herding patterns are reflected in the Seward Peninsula sites. Similarly, these sites expand our knowledge of the traditional subsistence round, an aspect of Bering Strait Eskimo culture with a major impact on reindeer herding.

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ALASKA NATIVE HISTORICAL SITES AND THE SUPERNATURAL WORLD

HANSEN, SUSAN K.

From 1975 to the present, the Cooperative Park Studies Unit of the University of Alaska documented the oral history and cultural value of several hundred historical sites in the Yukon-Kuskokwim Delta. The author worked in liaison with Calista Corporation in gathering and interpreting this information for the selection of historic sites under section 14(h)(1) of the Alaska Native Claims Settlement Act. Drawn from the still strong oral traditions of this Yupik-speaking area, the significance of these sites include supernatural beliefs as well as historical values.

Mythological and spiritual beings were and still are associated with mountains, streams, or tundra--places with some environmental peculiarity. Entire villages of mythological beings existed. In the western world these sites are associated with the supernatural, but for the Eskimo there was no dichotomy between the "natural" and "supernatural" world. All of the events and beings associated with the sites and described in legends--whether of hunter, dwarf, shaman, spiritual being or of a powerful nature force--were real and had been demonstrated to exist in the past.

This paper discusses the oral histories associated with the sites to help expand and illuminate the supernatural aspect of the ancestral beliefs.

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PHYSIOGRAPHIC ASPECTS OF CHUGACH ESKIMO SETTLEMENT PATTERN

Marcotte, James R.

This paper is based on research conducted by the Cooperative Park Studies Unit, University of Alaska, in connection with the Alaska Native Claims Settlement Act, Section 14(h)(1). Project goals include both field investigation of historic and cemetery sites and recording an ethnohistory of the Chugach Eskimo of Prince William Sound, Alaska. The relationship between archeological site location and shoreline physiography or local topography provides an important basis for studying Chugach settlement patterns. The sites, located on three major islands in eastern Prince William Sound, are in all cases found in association with one or a combination of several shoreline features. Dominant wind direction, water currents, extent of winter freeze and tectonic alterations all affect settlement directly through accessibility by watercraft and indirectly through the distribution of animal and plant resources. The Chugach were strongly oriented toward a maritime economy. To analyze intrasite feature and artifact distribution archeologists need an understanding of the geological processes that form and alter these features through time. This paper discusses the implications of these processes for cultural resource management, predictive site location models and recommendations for future research concerning Chugach settlement patterns.

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ALASKA NATIVE HISTORIC SITES: AN OVERVIEW OF THE ANCSA 14(h)(1) PROJECT

GRAUMAN, MELODY WEBB

The Alaska Native Claims Settlement Act of 1971 (ANCSA) created not only twelve Native regional corporations to distribute nearly one billion dollars and forty-four million acres of land but an opportunity to research and record Native historic sites. Under the provisions of Section 14(h)(1), the National Park Service, with a contract to the University of Alaska's Cooperative Park Studies Unit, has added 7,000 sites to the state survey. As part of the certifying process and in cooperation with the Bureau of Indian Affairs, these sites are evaluated using National Register criteria.

Since Native perceptions to land and history are different from the Euro-American, new and innovative interpretations of historic preservation philosophy have broaden the horizons of the movement in general. Place names, subsistence patterns, biotic resources, changing land use through time, and the all important intangibles values of deep feeling and association for the environment add immeasurable dimensions to our own understanding of the cultural landscape.

Over the last five years the ANCSA 14(h)(1) Project has explored these new areas throughout the state. Most recently we have focused in four geographic areas: Prince William Sound, Seward Peninsula, Arctic Village, and Southeast Alaska. Each site requires not only library and archival study but archeological and ethnographic data as well. In fact, in cases where there are no physical remains, oral history and local traditions provide the essential material for evaluation. Site Survey and National Register forms are completed for each site. Additionally, the cumulative data provides documentation for cultural overviews, interpretive programs, and scholarly reports fulfilling the requirements of the research design.

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THE ANCSA 14(h)(1) PROJECT RESEARCH DESIGN

ARUNDALE, WENDY H.

Archeologists working in the public sector increasingly recognize that their projects require appropriate, high-quality research designs. When a research project grows in scope and complexity, so must the research design that directs its progress, if the design is to meet these requirements. During the past year, the 14(h)(1) Project, a program to survey, document and research the "historic and cemetery sites" nominated by Alaska's Native Corporations under the Alaska Native Claims Settlement Act, has grown rapidly. This paper outlines the current research design for the 14(h)(1) Project and describes briefly how that design has grown to meet the expanding needs of the project.

The 14(h)(1) Project must provide data adequate both to document the sites for the land conveyance process and to meet the needs of broad research goals. The preliminary research design for the project was very general. The problem orientation focused on the processes affecting historic settlement pattern change in Alaska. The methods focused on survey techniques designed to collect the required prehistoric, ethnohistoric and ethnographic data in a consistent manner so that comparable information was gathered from all areas. In refined form, the initial design placed the problem in broader processual context and specified the necessary hypotheses and test implications more clearly.

The current research design draws heavily on earlier work, but expands the problem orientation of the design from one to three levels in descending levels of generality. Since processual problems remain one level, current design strengthens treatment of these problems. On a second level, the design sets out problems related to each specific area, for example the Bering Straits Region. On a third level, it delineates problems specific to particular sites or kinds of sites. The design also develops the methods and organization necessary to collect data relevant to these problems.

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ETHNOARCHEOLOGICAL SITE DOCUMENTATION IN THE NEETSI QWICHIN AREA OF ARCTIC ALASKA

LIBBEY, DAVID: AND MEDLOCK, LINDA M.

The Neetsi Qwichin, an Athapaskan-speaking people, have inhabited the area along the east fork of the Chandalar River in arctic Alaska since before the arrival of the white man. Their culture has been little studied, and while contact with western culture is on the increase, they are still considered a relatively isolated people, retaining a considerable amount of knowledge about their traditional ways.

During the summer of 1979, a study of Native cultural values was conducted in this area. Working out of the Native community of Arctic Village, an interdisciplinary team of archeologists from the Cooperative Park Studies Unit of the Univsitity of Alaska in Fairbanks and surveyors from the Bureau of Indian Affairs documented 23 historic and prehistoric sites that the local Neetsi Qwichin consider significant to their cultural heritage.

This presentation shows the site-documenting processes following a research design unique to the study of Native Alaskan cultures and includes (1) on-site interviews with knowledgeable Native elders, (2) archeological mapping of cultural features and (3) determination and surveying of site boundaries. This will be followed by a brief statement about the interrelationship between the sites and their significance both to Native peoples and the humanities in general.

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ORAL TRADITIONS AND STARVATION SITES ON THE YUKON-KUSKOKWIM DELTA

HANSEN, SUSAN

The writer visited eighteen Eskimo villages and recorded the oral history and traditions linked with now-abandoned villages and campsites while documenting historic sites under Section 14(h)(1) of the Alaska Native Claims Settlement Act. In open-ended interviews with older Yupik-speaking residents, life unfolded in enduring memories of the annual subsistence cycle and stories associated with these places. Many of the old villages and campsites are places where starvation occurred. The physical records of famine, such as large burial sites, are vivid reminders of man's dependence on the land.

In this paper several places of starvation are described and their oral history given. Many oral traditions are associated with the ways of surviving a famine period. In the retelling of these times, the means by which the people survived and slowly recovered their strength are described in detail. These oral traditions will continue to be remembered as long as subsistence is an important economic base in the Yukon-Kuskokwim Delta.

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NATIVE LIVELIHOOD AND DEPENDENCE ON THE NORTH SLOPE OF ALASKA

PEDERSEN, SVERRE; SCHNEIDER, WILLIAM; AND LIBBEY, DAVID

This paper reviews methodologies and findings of two years of multi-disciplinary research into the nature of social, cultural, ecological and physical factors of Native livelihood and dependence on lands within and adjacent to the National Petroleum Reserve--Alaska (NPR-A). In addition to time spent in each of the eight North Slope Borough villages, extensive field visits were undertaken in the company of local resource experts. These expeditions allowed for the collection of detailed ethnohistories on site use and occupation over time, as well as the integration of cultural and ecological site data.

Land-use mapping with (a sample of) residents in each of the eight villages made it possible to begin to cartographically describe individual villages and the overall regional subsistence geography.

Topics discussed include village profiles of the eight North Slope Borough villages, the importance of hunting and fishing sites and their use over time, the biotic resource complex and its utilization, the village and regional subsistence geography, the dynamics of the local economy and management considerations for the continued opportunity for traditional livelihood practice on lands within and adjacent to NPR-A.

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THE CHILKAT TLINGIT: A HISTORICAL OVERVIEW

SACKETT, RUSSELL H.

The Chilkat Indians remain one of the most traditional Northern Tlingit groups in southeast Alaska. Despite profound changes brought about by direct Euro-American contact, many of the old ways persist today. A rich oral history, extensive ethnographic studies, historical documentation, and archeological data demonstrate both continuity of tradition and encompassing changes in lifestyle since the late nineteenth century.

Historical sources outline the change and decline of Chilkat village life. Of four permanent villages existing at the turn of the last century, only one survives as a viable cultural entity today. However, eulachon fish camps associated with the abandoned village sites are still used by Chilkat people living in the Haines area. Eulachon fishing and other procurement strategies demonstrate that certain aspects of the traditional subsistence economy persist as a focus of contemporary life.

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THE ASSESSMENT OF FRESHWATER INUNDATION IMPACTS ON CULTURAL RESOURCES: AN EXPERIMENTAL APPROACH

WARE, JOHN A.

The National Reservoir Inundation Study, a multidisciplinary research project to assess the impacts of freshwater inundation on archeological and historic cultural resources, is currently conducting a series of laboratory and field experiments to measure the biochemical and mechanical impacts on submerged cultural resources. This paper discusses the design of these experiments, and presents some preliminary experimental results.

One of the most important questions being addressed by the Reservoir Inundation Study are the effects of freshwater chemical and microbiological variables on the deterioration rates of common cultural materials. A two-stage experiment was designed to investigate these relationships. The first stage consists of a series of controlled water chemistry experiments in which various classes of cultural materials (stone, ceramics, shell, bone, wood, vegetal material, and pollen) have been immersed in buckets containing common water chemicals (Ca, Mg, Na, CO_3, HCO_3, Cl, SO_4, dissolved SiO_2, Fe, and dissolved O_2), in both normal and highly concentrated deionized water solutions.

The second stage of the biochemical experiment is being conducted at Brady Reservoir, Texas, where samples of cultural materials identical to those immersed in the laboratory have been immersed at various depths and under varying aerobic and anaerobic conditions in the reservoir.

It is hoped that with the laboratory samples serving as a control for water chemical impacts, a comparison of the field and laboratory samples will isolate the specific effects of microbiological degredation. Although final comparisons of field and laboratory samples will not occur until the Spring of 1980, preliminary indications are that there is considerable variability in deterioration rates across chemical solutions, and vegetal samples are deteriorating much faster in the field than in the laboratory.

In addition to the biochemical experiments, Inundations Study archeologists are conducting a series of laboratory wave-tank experiments at the Bureau of Reclamation Engineering and Research Center in Denver in order to assess the effects of wave and current action on cultural resources along the reservoir shoreline. The wave-tank experiments have been designed so that such factors as wave height and period, geologic slope and constituency, and the nature of the archeological remains can be systematically varied to permit the isolation and measurement of mechanical relationships critical to the preservation and destruction of archeological sites on a reservoir shoreline.

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TRIAL BY FIRE: EFFECTS OF NPS BURN PROGRAMS UPON ARCHEOLOGICAL RESOURCES

Roger E. Kelly* and Jim Mayberry**

Prescribed management fires and greater emphasis on wildfire research within some Park System areas have yielded many data regarding the role of fire in ecosystem processess. At the same time, known number, location, and significant values of historic and prehistoric archeological resources have dramatically increased for many park areas also. Although incompletely inventoried, hundreds and thousands of archeological sites within parks are likely eligible for nomination to the National Register of Historic Places as mandated by historic preservation law and Service policy. The development of Resource Management Plans for many areas has provided an opportunity for formalization of many research actions, including those of fire ecology studies, and such Plans have required compliance with Federal resource protection laws. This paper is focused on the possible beneficial or adverse effects of vegetation fires upon scientific research values of archeological resources.

Within the Western Region, a research design testing the effects of prescribed management fires upon archeological materials has been prepared by regional office scientific personnel. Test plots have been established in several park project areas and cultural materials placed within plots have been subjected to ground surface fires. Laboratory tests of combustion temperatures and heat treatment of artifacts have yielded useful data.

This research will form a basis for determining instances in which the following management decisions may be made:

1. Both natural and cultural resources will be protected through proper planning of fire ecology projects;
2. Cultural resources as represented by archeological materials and sites will/will not be impacted during park programs to restore or preserve natural vegetation ecological processess;
3. Natural fire processes may be discontinued in order to preserve some archeological resources.

This paper will discuss preliminary test results and tentative conclusions regarding the three aspects above.

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AQUATIC BIOLOGY

AQUATIC ECOSYSTEMS BIG BEND NATIONAL PARK: BIOLOGICAL AND CHEMICAL INDICATORS OF WATER QUALITY

LIND, OWEN T. and CAROL A. BANE

Eighteen aquatic ecosystems were periodically monitored for one year. These included tinajas, marshes, springs (thermal and non-thermal), Tornillo Creek and the Rio Grande. The Rio Grande, lower elevation springs near the Rio Grande, and associated marshes were typically hard water with higher concentrations of common cations, including heavy metals, than was Tornillo Creek, the tinajas, and the higher elevation springs. No ionic concentrations were sufficiently great so as to cause stress upon the biotic communities; however, copper and zinc concentrations in some systems approached or exceeded the upper limit for some sensitive species. Nitrogen and phosphorus concentrations were measured as indicators of cultural organic loading with the potential for producing nuisance algal growths. Undesirably great concentrations of nitrogen occurred in one spring and in Tornillo Creek. Several systems had undesirable concentrations of phosphorus and heavily impacted Boot Spring was exceptionally great on one date.

Aquatic invertebrates from 172 taxa were collected. Several biological indicators of clean water conditions occurred in most of the larger aquatic ecosystems although several taxa associated with lower quality water occurred in the Rio Grande and it's associated marshes.

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ESTABLISHING BIOLOGICAL CRITERIA FOR WATER QUALITY MANAGEMENT IN THE VOYAGEURS NATIONAL PARK

HARGIS, JACK R.

Carved by glaciers from some of the oldest bedrock at the earth's surface, the Voyageurs region holds very "soft" waters, low in mineral content, which are quite susceptible to human influence. With intensified use of the Voyageurs National Park, Minnesota we have an ideal opportunity--indeed, an obligation, to discover how visitor pressure affects the lakes found there. The plankton community serves as the biological lens through which impact will be evaluated. Attributes of the community structure and function in twenty-five lakes within the park are being recorded and interpreted with respect to lake morphology and physical and chemical water quality features such as temperature, concentrations of dissolved oxygen and plant nutrients, alkalinity, hardness, and pH. Each of these lakes contain their own characteristic fish populations and receives its own degree of visitation. The constraints of primitive/wilderness conditions have been overcome in the design of a sampling program which operates from canoe, utilizing lightweight equipment and generating large numbers of lightweight, easily backpacked samples.

Zooplankton organisms are key indicators of change within the monitoring framework established by this research. Their short generation time and high reproductive potential make zooplankton responsive to rapid changes in water quality. The presence of certain species and their growth and reproductive rates are used along with indices of zooplankton community diversity to characterize the typical summer season development of the aquatic food webs of each lake. The response of *Daphnia galeata mendotae* and *Diaptomus sicilis*, species found in most of the park's waters, are used to cross correlate biological conditions between regions within the park. Variations in *Daphnia* densities from 1800 to 12,000 m^{-3} (with anywhere from 1 to 24% of the individuals gravid, egg-bearing females) and in *Diaptomus* densities from 340 to 53,000 m^{-3} (1 to 10% gravid) provide an example of the data spectrum being quantified in the formation of a biological index of water quality for the park. Zooplankton community diversity values range from 2.0 to 2.5 (Shannon-Weiner Index). A photographic identification file of the park plankton is also being developed to aid in training park service personnel to carry on the monitoring aspect of this study beyond the tenure of the present contract.

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ADAPTIVE STRATEGIES OF AQUATIC ORGANISMS IN DEATH VALLEY WATERS

COLBURN, ELIZABETH A.

To most people, Death Valley symbolizes extreme drought and heat. Yet water can be found throughout the valley. The springs, streams, and marshes of Death Valley provide a variety of physical conditions -- fresh and hypersaline waters, temperatures from freezing to over 37° C, permanent springs and ephemeral pools. Some of these habitats fluctuate widely, others remain stable through the year, but all support unique biological communities. Populations of endemic fishes, hydrobiid snails, and many species of aquatic insects occur in Death Valley waters. These organisms possess life history modifications and physiological adaptations which allow them to survive where their freshwater relatives cannot. This report considers some specializations of organisms which inhabit Salt Creek (a saline habitat) and Saratoga Springs (a low-salinity habitat).

Three patterns of distribution in relation to salinity are seen in Death Valley waters. Many insects and crustaceans are found only in low-salinity habitats such as Saratoga Springs. In contrast, some corixids and dipterans are restricted to saline waters. A third group of species, including the caddisfly larva Limnephilus assimilis and many odonates and beetles, occurs both at low salinities and at salinities found at Salt Creek (10-45°/$_{oo}$; sea water is 35°/$_{oo}$). These distributions broadly reflect physiological capabilities. The freshwater organisms cannot maintain constant internal osmotic and ionic levels at high external salinities, while salt-tolerant organisms possess physiological mechanisms for hypo-osmotic and -ionic regulation. The extent of physiological adaptation is related to life history. For example, the caddisfly regulates the composition of its body fluids at salinities from fresh water to 25°/$_{oo}$, but it cannot tolerate higher salinities for extended periods of time nor survive at high temperatures. However, this species' life history strategy involves rapid larval growth in winter and adult reproductive diapause in summer, with oviposition delayed until fall, allowing avoidance of the summer extremes of salinity, temperature, and desiccation which are experienced by year-round residents of Salt Creek. Some other insects and crustaceans aestivate as resting eggs, hatching in fall as water levels increase and temperatures decrease. Thus, many combinations of adaptive strategies contribute to survival of aquatic organisms in Death Valley.

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EFFECT OF BRINE FLY GRAZING ON THERMAL ALGAL-BACTERIAL MATS OF YELLOWSTONE NATIONAL PARK.

Wiegert, Richard G.* and Wickstrom, Conrad E.**

The biological communities found in alkaline thermal outflows of Yellowstone National Park are structurally simple, yet possess a full complement of ecological interactions. We determined the effects of animal grazing on decomposition rate and bacterial numbers in these systems. The gelatinous mats of blue-green algae and bacteria that develop in the streams add biomass at the surface more rapidly than it is anaerobically degraded. This inequality causes flow diversion and an exposed algal surface. The microenvironment of these cool "islands" is altered as adults and larvae of brine flies invade and feed on the mat. The grazing activity had a marked effect on the mat by destroying its structure, stimulating an increase in biomass and increasing the aerobic heterotrophic bacterial populations.

The effect of grazing was studied by comparing hot-ungrazed (HUG) and cool-ungrazed (CUG) controls with mat (CG) that was cooled and open to flies (Paracoenia turbida). We measured biomass changes (ash-free dry wt) and changes in bacterial numbers. Algal and bacterial species of all mats did not change. Biomass was unchanged for three weeks in controls. Numbers of bacteria remained unchanged in the CUG control but decreased more than 90% in the HUG control. Grazing by ephydrid flies initially increased the biomass of the mat and the numbers of unicellular heterotrophic bacteria. When flow was reestablished to the CG diverters both biomass and bacterial numbers per mg AFDW declined. These results suggest short-term stimulation of net photosynthesis by grazing, possibly related to promotion of bacterial activity resulting in release of essential nutrients and/or free CO_2. In the natural system seepage of these recycled nutrients may stimulate primary production of adjacent mat causing flow diversion and initiation of grazing again. The long-term effect is solubilization, washout of biomass, and initiation of successional growth of the mat.

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DISTRIBUTIONAL PATTERNS OF AQUATIC MACROINVERTEBRATES IN THE KINTLA DRAINAGE, GLACIER NATIONAL PARK.

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Biota response to environmental parameters is often robust and discrete. Specific biological and physical-chemical parameters may determine large scale distributional patterns of macroinvertebrates within a drainage basin. Although some parameters are indirectly correlated with actual faunal response, several specific parameters directly integrate to establish ecological differentiation.

The distributional patterns of aquatic macroinvertebrates along the longitudinal gradient were determined in the Kintla drainage, Glacier National Park, a wilderness area characterized by first order streams beginning in high alpine meadows and subsequent passage through two large oligotrophic lakes. The partially open canopied lake outlet stream leaving the drainage enters the North Fork Flathead River. Investigations of four sampling sites between elevations 1677M and 1067M were initiated in 1978. Temperature, gradient, temporal dynamics, organic carbon dynamics, and stream trophic status were investigated as the primary determinants in the distributional response by lotic macroinvertebrates.

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THE INFLUENCE OF KOKANEE SALMON MIGRATIONS AND HUMAN USE PATTERNS UPON THE HYDROCHEMICAL AND BACTERIOLOGICAL CHARACTERISTICS OF LOWER McDONALD CREEK, GLACIER NATIONAL PARK, MONTANA

FOGGIN, III, G. THOMAS
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A unique management situation presently exists within Glacier National Park where a non-native kokanee salmon (Oncorhynchus nerka kennerlyi) spawning run occurs in a stream reach situated within an area of concentrated human use at the western entry to the Park. In addition to the village of Apgar, a horse pasture and a sewage sprayfield lie adjacent to lower McDonald Creek below Lake McDonald. The migrating salmon, estimated between 75,000 and 125,000 in population, have attracted progressively larger numbers of migrating bald eagles (Haliaeetus leucocephalus alascanus) who prey upon the dying fish. In addition to the 618 eagles recorded in 1978, other feeders include grizzly bear, white-tailed deer, coyote, otter, and an increasing number and variety of gulls and ducks. This fall spectrum of wildlife has drawn additional off-season visitors to the Apgar-West Glacier area of the Park. This study is designed to: 1) determine the annual hydrochemical patterns of both the major and the ecologically important ions; 2) evaluate the influence of salmon decomposition upon seasonal hydrochemical concentrations; 3) address the issue of fish migration as a nutrient cycling mechanism; 4) evaluate the effect of human use upon bacteriological and hydrochemical patterns; and 5) provide baseline data for the management of this ecologically congested area. Five temporary water quality stations have been established on McDonald Creek to provide information for: 1) a comparatively unaffected stream reach above Lake McDonald; 2) the lake outlet; 3) below the high-use Apgar area; 4) below the major portions of the spawning area above the pasture-sprayfield; and 5) below the pasture-sprayfield. Field sampling began in June 1979. Preliminary data and observations will be presented and discussed.

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SPECIES COMPOSITION AND VERTICAL DISTRIBUTION OF PELAGIC ZONE PHYTOPLANKTON IN CRATER LAKE,OREGON: 1940 - 1979

LARSON,DOUGLAS W.* AND GEIGER,N.STAN**

Crater Lake,Oregon,with a maximum depth of nearly 600 meters, ranks as the deepest lake in the United States and seventh deepest in the world. Limnological studies of the lake in 1940 indicated that (1) phytoplankton,or planktonic algae,was most abundant at a depth of 75 meters, (2) virtually no phytoplankton existed in the surface to 20-meter layer, (3) most phytoplankton consisted of filamentous,blue-green algae (Anabaena sp), and (4) diatoms constituted only about 15% of the total phytoplankton collected.

Similar studies in 1978 and 1979 found conditions to be considerably different than those reported in 1940. Accordingly,as determined in 1978-79, (1) diatoms are the predominant phytoplanktonic form, (2) Anabaena sp is no longer present, (3) surface waters contain an abundance of phytoplankton,particularly Nitzschia gracilis, (4) taxa diversity is greater,with at least 50 species of phytoplankton identified, (5) the vertical distribution of phytoplankton varies among species, and (6) equally large numbers of organisms occur at various depths throughout the vertical water column.

Dissimilar findings between the 1940 and 1978-79 studies are due,possibly, to different sampling and analytical techniques or, more significant perhaps,alterations in lake quality,especially with regard to certain physical-chemical properties capable of influencing composition,size and depth distribution of phytoplankton populations.

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SPECIES DIVERSITY IN BENTHIC INVERTEBRATE ASSOCIATIONS OF THE KAWEAH RIVER IN SEQUOIA NATIONAL PARK, CALIFORNIA

ABELL, DANA L.

A standardized reconnaissance collecting method employing timed samples was used to describe benthic invertebrate faunas at nearly 100 stations on relatively undisturbed montane tributaries of the Kaweah River in Sequoia National Park in 1976 and 1977. The data supported the two familiar generalizations that species diversity, expressed simply as the number of taxa present, is proportional to overall abundance and that diversity and abundance increase with size of the stream. The Shannon-Wiener index of diversity per individual confirmed the obvious facts that the smallest streams display very low diversity and that the largest have unusually high diversity, but this index revealed no discernable pattern in the wide range of medium-sized streams in the Kaweah drainage system. A new and simpler method of expressing the relation between diversity and abundance, called the method of faunal profiles, did make it possible to identify a normal sequence of faunas, ranging from the depauperate ones of small, temporary streams to the exceedingly diverse ones of the free-flowing main stem of the river in the Sierra Nevada foothills. A faunal profile is a series of histograms of counts of individual taxa arranged in order of decreasing abundance. Two major patterns of deviation from the normal sequence are noted and their possible relation to low nutrient levels and various types of natural or man-caused disturbance is discussed. The Kaweah data suggest an unusually high degree of individuality in benthic associations in the many tributaries of the river. The basic types of faunal profiles appear to be consistent despite important differences in the species composition of the associations.

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A METHOD FOR ANALYZING PHYSICAL, CHEMICAL, AND BIOLOGICAL ASPECTS OF SMALL COLD-WATER STREAMS FOR BASELINE INVENTORY

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Aquatic inventory information is obtained utilizing several remotely related evaluations formulated by component and related to a prescribed geographic location. Physical stream habitat evaluations are initiated utilizing 121.9 m sampling stations along stream reaches. A Procedure for Habitat Inventory and Appraisal by Dunham and Collotzi, Fishery Biologists, National Forest, is applied. This modified method of analysis evaluates fishery habitat as a percentage of optimum requirements for the "perfect stream" for salmonids. An aesthetics rating is incorporated into the assessment using a method described by Litton (1968). The aesthetics of water in a landscape as derived from the interrelationships of the components of water, vegetation, landform, and human effect are rated using this method.

A stream reach inventory and channel stability evaluation for each station is conducted using the method described in the Stream Reach Inventory and Channel Stability Evaluation handbook produced and used by the U.S. Forest Service, Northern Region. This method was developed to systemize measurements and evaluation of the resistive capacity of mountain stream channels to the detachment of bed and bank materials. A riffle analysis is further incorporated into the inventory which consists of measuring the width of each riffle encountered at five cross channel transects (30.47 m apart), recording the bottom composition of the riffle, and measuring depths and velocities at regular intervals across the riffle.

Seventeen parameters of water quality are analyzed at stations at least twice (spring and fall) during the year. Aquatic insects are collected with a one-meter wide kick screen using a 360 micron mesh Nitex netting at the same sampling frequency. Qualitative and quantitative evaluations are undertaken classifying all aquatic insects and taking Stonefly and Mayfly Orders to species when possible. Fish population information is gathered by electrofishing the 121.9 m stations as frequently as possible during the year. Grab sampling techniques may be utilized for the three above evaluations or a systematic schedule of monitoring may be applied depending upon what the investigator desires from inventory efforts. Stream meander intervals (active or total) are measured at each stream reach or station from U.S. Geologic survey 7.5 minute quadrangle maps with the aid of an opaque projector. Stations are permanents marked and photographed from different angles.

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PRELIMINARY OBSERVATIONS ON FISH PREDATOR-PREY INTERACTIONS IN THE SHARK RIVER ESTUARY, EVERGLADES NATIONAL PARK

SCHMIDT, THOMAS W.

In this paper, preliminary results are reported on a fish food habits study currently in progress in the Shark River estuary, Everglades National Park, Florida. The purposes of the study are to obtain quantitative information on the energy pathways and trophic interrelationships of dominant, non-game, epibenthic fish, shrimp, and crabs. It is part of a larger project to identify the driving variables on the biotic resources within the coastal ecosystems of South Florida National Park Service areas. These data are essential in our understanding of how these estuaries respond to external parameters--fishing pressure, and natural or man-made environmental variation. The selection of study sites and standard sampling techniques focused on the principle prey items of pinfish Lagodon rhomboides, silver jenny Eucinostomus gula, silver perch Bairdiella chrysura, Lane snapper Lutjanus synagris, pigfish Orthopristis chrysoptera, blue crab Callinectes sapidus, and pink shrimp Penaeus duorarum. Types of sampling gear employed, the design, fabrication, and installation of mechanical hardware required to accommodate the samplers; and the procedures used, including water quality parameters measured and sampling frequency and intervals are discussed. A literature search on potential predator-prey organisms was conducted through park and university libraries. A rapid, standardized approach for laboratory procedures was developed utilizing the same methods to measure the food organisms and those taken in concurrent biotic surveys. Required information on the individual predators included numbers, length, weight, sex, reproductive condition, and species of food organisms being eaten. A data manipulation and processing system was developed on a Wang 2200 minicomputer to store and retrieve stomach contents data sets and to compute and display the statistical summaries of the prey organisms including numerical and percent composition (frequency of occurrence), abundance and biomass of the food items. In addition the storage of important life history information on other predator characteristics was facilitated. Prey organism collected between March and June, 1979, indicated that most of the diet items fell into three categories: mussels Brachidontes exustus; polychate fragments; and gammarid or caprellid amphipods. Future work plans are to determine if feeding preferences are due to differences in prey availability resulting from natural or man-made environmental variation. With this information in hand the park managers who are responsible for managing natural resources can direct their interests towards understanding what regulates the stability of these ecosystems.

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EFFECTS OF GEOTHERMAL EFFLUENTS ON THE FISHERY OF THE FIREHOLE RIVER, YELLOWSTONE NATIONAL PARK

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The Firehole River of Yellowstone National Park receives substantial amounts of heated effluents from the numerous geothermal features of the drainage. Originally barren of fish because of impassable waterfalls near its mouth, the river's fishery began with the introduction of trout in 1889. Through the years angling regulations were liberal and the river became widely known as a blue-ribbon trout fishery, especially for abundant brown trout (Salmo trutta). Stocking remained the principal management through 1955 when the fishery became completely dependent upon natural reproduction.

A fisherman survey in 1969 revealed significant changes in the Firehole River fishery since investigations of the mid-1950's; rainbow trout (Salmo gairdneri) had replaced brown trout as the most common fish caught and catch rates for brown trout were markedly reduced. More restrictive angling regulations were instituted in 1970 but subsequent investigations revealed no significant changes in the fish populations.

We conducted investigations between July 1974 and February 1976 to determine what effects geothermal effluents may have on Firehole River trout. Available data suggested water temperatures in the lower river exceed suitable levels for trout, yet this area supports nearly all the river's angler use and harvest.

Results of our study indicate elevated temperatures impair seasonal gonadal development of both species, particularly brown trout. Rainbow trout have evidently adapted to the ambient temperature regimen by spawning during early winter rather than the typical spring period. Growth rate is rapid in the warm water but few fish attain the minimum legal size of 406 mm (16 inches). This probably reflects the limits on growth set by interactions of high metabolic requirements in the warm water and the nutritional value of an invertebrate diet.

We speculate that changes in the Firehole River fishery evident since cessation of stocking are the result of differing reproductive success between brown and rainbow trout in the geothermal waters. This hypothesis is supported by our trout population surveys that indicate rainbow trout is now the most numerous species in the warm water.

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DIPHYLLOBOTHRIUM CORDICEPS: A TAPEWORM PROBLEM IN YELLOWSTONE LAKE FISHES. NEW INVESTIGATIONS INTO THE LIFE CYCLE.

KINGSTON, NEWTON,* KENNETH L. DIEM† and DOUGLAS MITCHUM¶

Diphyllobothrium cordiceps has been known from the Yellowstone Lake since 1872 when Leidy described plerocercoids from cutthroat trout, Salmo clarki, collected by the Heyden expedition to the Montana Territory and adjacent areas in 1871.

Various aspects of the life cycle of this tapeworm are well known: Adult worms are found in the intestine of white pelicans (Pelicanus erthrorhynchus) and California gulls (Larus californicus) on and around the Molly Islands, in the southeast arm of Yellowstone Lake. The same or similar species of tapeworm also infect grizzly (Ursus horribilis) and black bears (Ursus americanus) in Yellowstone Park. Cutthroat trout and other salmonids are infected with plerocercoids which on ingestion infect pisciverous birds and bears. Eggs from adult worms pass out of definitive hosts in the feces.

Previously unknown aspects of the life cycle include development of the eggs, infection of first intermediate hosts (copepods), and mode of infection and development in the fish second intermediate host.

Investigations in 1978-79 show development of the eggs takes place in 15-21 days when the eggs, in lake water, are agitated and aerated (10-21 C). Coracidia hatching from the eggs are infective to copepods when ingested. In Eucyclops agilis, development of procercoids (apparently) takes place in 18-21 days. Infected copepods were fed to laboratory reared grayling (Thymallus arcticus) and hatchery reared cutthroat trout (Salmo clarki) with, as yet, unknown results. Plerocercoids from naturally infected cutthroat trout when fed by stomach tube to hatchery reared cutthroat reestablished themselves in this host.

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SOME ASPECTS OF THE LIFE HISTORY AND SEASONAL DISTRIBUTION OF THE SPECKLED DACE, RHINICHTHYS OSCULUS GIRARD, IN THE COLORADO RIVER, AND SELECTED TRIBUTARIES, GRAND CANYON NATIONAL PARK, ARIZONA.

USHER, HOWELL D., CAROTHERS, STEVEN W., JORDAN, JAMES W., MINCKLEY, C. O.

Speckled Dace, Rhinichthys osculus Girard, from Grand Canyon National Park, Arizona, were studied from November 1977 through October 1978. In this paper we discuss aspects of seasonal distribution, breeding, age and growth, food habits, and parasitism of Speckled Dace in the Colorado River and its major tributaries.

Population densities of Speckled Dace in the tributaries were lowest in the fall and winter, possibly as a result of predator (Rainbow Trout) avoidance. Breeding occurred during the months of April and May at water temperatures of 17 to 23°c. Fecundity values ranged from 932 to 1440 eggs per female. These fish are short-lived, generally attaining an age of not more than two years. Mean annual increment of growth was 50.1 mm in the first year and 24.1 mm in the second year. Growth appeared to be greatest in the early summer months. Age Class I (one year old fish) dominated the sample. In the Grand Canyon dace are predaceous and apparently forage nocturnally. Their diets consist largely of benthic invertebrates; however Cladaphora sp., a filamentous green algae, and terrestrial insects were also utilized. Speckled Dace in Kanab Creek, during the August and October sampling periods, were found to be infested with the anchor worm Lernaea cyprinacaea, a parasitic copepod.

This study was conducted as partial fullfillment of a Bureau of Reclamation Research Contract (No. 7-07-30-X0026) to the Museum of Northern Arizona, Department of Biology.

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OBSERVATIONS ON THE HUMPBACK CHUB, *GILA CYPHA*, WITHIN THE COLORADO AND LITTLE COLORADO RIVERS, GRAND CANYON NATIONAL PARK, ARIZONA.

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The humpback chub, *Gila cypha*, was first described from Bright Angel Creek, a major tributary of the Colorado River within Grand Canyon National Park in 1946. Little information has been obtained on the chub which is currently included on the federal list of endangered species. The following presentation provides data on the humpback chub population, which exists in the mainstream Colorado and Little Colorado Rivers within Grand Canyon National Park. Data presented include information on humpback chub distribution within this region, as well as observations made on the age and growth, length-weight relationships, condition, reproduction, and ectoparasite infestation of this species. Additionally, behavioral observations are presented as are data pertaining to habitat use and interspecific associations. The reasons for the decline of this species and other "big river fishes" can be associated with the altered flow regime of the Colorado River in Grand Canyon National Park.

This research was supported by contracts to the Department of Biology, Museum of Northern Arizona from the Bureau of Reclamation, Boulder City; National Park Service, Grand Canyon; and the Office of Endangered Species, Fish and Wildlife Service.

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THE IMPLICATIONS OF A TAXONOMIC STUDY OF BROOK TROUT SALVELINUS FONTINALIS (MITCHILL) ON THEIR MANAGEMENT IN THE GREAT SMOKY MOUNTAINS NATIONAL PARK

ESTES, R. DON

The population of brook trout in the Great Smoky Mountains National Park has declined in recent years to the extent of perhaps becoming extinct in the Park. It has long been the contention of many biologists that this population represented a unique taxonomic group, possibly a sub-species or even species. Because of the concern for the survival of this population, the only indigenous salmonid in the region, a management plan supported by a research program was initiated in 1975-76. Included in the plan was the proposal that the "Southern Appalachian" brook trout be considered for endangered status, even though there were insufficient data to support a sub-species designation for these fish. This study was initiated in 1976 to determine the taxonomic status of brook trout in the Smokies utilizing morphometric and meristic analyses and electrophoretic techniques.

Electrophoretic data were obtained from 1204 specimens collected from 35 allopatric populations from nine states and the Park. Examination of 14 enzymes representing an estimated 29 genetic loci revealed only slight differences between the gene frequencies of the populations sampled. No specific or sub-specific differentiation was indicated. The meristic and morphometric analysis included 739 specimens collected from 34 populations, and 25 meristic and morphometric characters were assessed for each fish. No significant differences between the populations were found. It was concluded that no significant genetic differentiation existed between brook trout from the Great Smoky Mountains National Park and the other brook trout populations examined. However, the possibility remains that there are one or more strains of brook trout in the Park, since this study was limited to methodologies lacking criteria for identifying strains or races.

The results of this study give insight into the degree of inbreeding among brook trout in the Park and the impact of possible stocking in the future. Management plans can be more flexible knowing that Park brook trout are not a sub-species.

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POPULATION RESPONSES OF BROOK TROUT CONCURRENT WITH REDUCTIONS IN NUMBERS OF EXOTIC TROUT FROM AREAS OF SIX STREAMS IN THE GREAT SMOKY MOUNTAINS NATIONAL PARK

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RIDLEY, BROMFIELD
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Native brook trout have declined in abundance and distribution in the Great Smoky Mountains National Park since about 1900. These decreases are attributed to logging and poaching prior to the establishment of the Park in 1936 and to immigration by rainbow trout and brown trout into allopatric brook trout waters. Attempts at rehabilitating several brook trout populations are discussed in this paper.

Exotic rainbow trout and brown trout populations were reduced in abundance and total weight by electrofishing in six headwater streams in which the exotics were sympatric with native brook trout. Each study area was upstream from a natural obstruction -- waterfall or cascade. Exotics were removed each summer from 1976 to 1978. Captured brook trout were marked and returned to the streams. Brook trout populations have responded to the removal of the exotics by increasing in abundance and total weight. Expected concomitant declines in total weight and abundance of exotic trout were dramatic in some cases but were not as apparent in others. Thus far the exotics could not be completely removed from the streams by the two-man (one shocker) team. Additional field work is scheduled for this summer.

Natural obstructions were measured and their effectiveness evaluated for preventing upstream passage by exotic trout. In some cases, cascades may be more effective barriers than similar sized waterfalls.

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POPULATION STRUCTURE OF ALLOPATRIC AND SYMPATRIC RAINBOW TROUT AND BROOK TROUT IN SELECTED STREAMS IN THE GREAT SMOKY MOUNTAINS NATIONAL PARK

SWEENEY, JEFF*
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Between 1900 and 1977 the stream miles inhabited by allopatric native brook trout in the Great Smoky Mountains National Park shrank from 425 to 125. A considerable amount of this mileage was lost during the logging era from 1903 to about 1936. Since then, however, continued losses have been attributed to invading populations of rainbow trout -- an exotic.

The objective of this study is to evaluate the invasion characteristics and processes of the rainbow and to determine how the rainbow, in sympatry, affect the brook trout populations. Presently, five of ten study streams have been sampled with back-pack electrofishing units. Preliminary analyses reveal that structural differences do exist in actively invading rainbow populations between sympatric and allopatric stream sections. It appears that large rainbow trout, often 200+ mm in total length, may lead the invasions. Very few small fish of either species are found in the sympatric sections relative to allopatric sections. All rainbow captured have been preserved and will be analyzed for age, sex, and prespawning fecundity. The general invasion strategies by the rainbow will be discussed.

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ENVIRONMENTAL CONCERNS IN URBAN, IMPACTED PARKS

ANALYZING PEST MANAGEMENT PRACTICES USING ENERGY ANALYSIS

OLKOWSKI, WILLIAM and OLKOWSKI, HELGA

Pest management practices consume energy when labor, fuels, materials and equipment are used. This paper provides an overall conceptual framework within which field managers responsible for pest control decisions can conduct their evaluations using energy considerations. Conventional pest control is contrasted with integrated pest management and the still more inclusive approach of ecosystem management. A definition and short history of integrated pest management is presented. The laws of thermodynamics, related concepts such as entropy and antientropy are discussed, and system and ecosystem definitions are used. Methods for developing net energy assessments are provided for managers interested in making their own calculations. Sample calculations are illustrated.

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PROGRESS IN ELM TISSUE CULTURE

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American elm (Ulmus americana L.) has been rendered an unacceptable tree for planting because of Dutch elm disease and phloem necrosis. While there is little resistance to these diseases in the tetraploid (2n=56 chromosomes) American elm, excellent resistance is found in the diploid (2n=28 chromosomes) Siberian elm (Ulmus pumila L.). Unfortunately, the Siberian elm does not have American elm's desirable ornamental characteristics and it is sexually incompatible with American elm. The goal of the research described in this paper is to combine American elm's ornamental characteristics with Siberian elm's disease resistance in a two phase project. In the first phase, anther culture and the selection of twin seedlings are being investigated for their potential in isolating American elm plants with a 2n=28 chromosome number. In the second phase, the techniques for protoplast fusion of Siberian elm and American elm are being developed.

Eight hundred cryptic twins and triplets were selected from 250,000 American elm seeds germinated on cheesecloth on greenhouse benches. The smaller individuals (putative 2n=28 chromosomes) were cultured on Durzan and Lopushanski's elm tissue culture medium. Root tips were excised for chromosome counts using standard squash techniques and giemsa stain. To date, no haploid plants have been found from the 40 cultures on which chromosome counts have been made. Over 10,000 anthers from 8 American elm trees and from five different stages of microsopore development were plated on 27 different media. The haploid nature of callus from several anthers has been confirmed by chromosome counts. This is the first reported successful culture of haploid callus from American elm anthers. Attempts to regenerate plants from the haploid callus have failed. After telophase II but before the first mitotic division was the best stage to plate the anthers and a media containing 1/4 Murashige and Skoog's formula plus a potato extract solution was the best culture media. For the first time, protoplasts from American elm and Siberian elm cotyledons and callus were isolated. Combinations of cellulase, hemicellulase, and pectinase enzymes were used. While viability of the protoplasts was verified using exclusion staining with Evans blue and methyl blue, little or no protoplast growth occurred. Using techniques modified from Kao's protocol, Siberiar elm cotyledon protoplasts containing green chloroplasts were fused with American elm callus protoplasts without chloroplasts. Work is in progress to isolate and culture the hybrid protoplast fusion products.

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STRESS FACTORS AFFECTING THE GROWTH OF TREES IN INDEPENDENCE NATIONAL HISTORICAL PARK

Rhoads, Ann F. and Meyer, Paul W.

During a three year study of vegetation in Independence National Historic Park we have identified a number of abiotic and biotic stress factors which limit the successful growth of trees. Subsequently, recommendations have been developed for improved tree health. INHP includes over 1900 trees and shrubs in a variety of urban planting sites.

Soil factors including poor drainage, compaction, alkalinity from buried rubble, and salt accumulation were severe limiting factors. Mechanical wounds were frequent on curbside trees (from traffic) and lawn specimens (from mowing equipment) and led to serious canker and decay problems in many cases. Photochemical air pollutants caused foliar injury to certain sensitive trees.

Of particular interest was the occurrence of termites in both young, newly planted trees and established, otherwise healthy trees at several locations. Eastern Subterranean Termites were found to have invaded Ginkgo (Ginkgo biloba) and Thornless Honey Locust (Gleditsia triacanthos var. Inermis) under cover of the paper trunk wrap used to protect the trunks from sunscald. Scale insects were a serious problem on oaks (Quercus sp.) and other species especially in curbside planting sites. Borers are also a problem in such species as Red Oak (Quercus rubra), Lilac (Syringa vulgaris), Black Locust (Robinia pseudoacacia) and Green Ash (Fraxinus pennsylvania). Other insect problems of widespread occurrence included aphids and lacebugs.

A severe outbreak of Bleeding Necrosis Disease has necessitated replacement of a large planting of sweetgums (Liquidambar styracifluga) in Independence Mall. This canker disease, caused by the fungus, Botryosphaeria ribis, is apparently associated with unfavorable environmental conditions such as drought and low temperatures. Other diseases of major significance were Anthracnose of London Planetrees (Platanus acerifolia) and Fireblight on crabapples (Malus sp.) and pears (Pyrus sp.).

As a result of our observations we have made recommendations regarding planting site preparation, species selection, and cultural practices for improved tree health. Techniques such as raised planting beds and expanded tree pits may be used to create more favorable growing conditions for curbside trees. The tendency to create monocultures in city plantings should be avoided. Many lesser known tree species show promise for reliable performance under urban conditions and should be planted more frequently.

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A PRACTICAL THERAPEUTIC TECHNIQUE FOR DUTCH ELM DISEASE

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Dutch elm disease (DED), is a serious threat to the many historic, memorial and other high value elms within the National Capital Region (NCR).

In the past, the extreme virulence of DED has precluded therapy as a viable alternative to tree removal. However, in an attempt to save valuable trees and reduce the number of DED losses, the Ecological Services Laboratory, in cooperation with the United States Department of Agriculture Forest Service, has been evaluating a therapeutic technique which combines fungicide injection with removal of diseased limbs.

Trunks of infected elms were pressure injected (70 p.s.i.) with MBC-HCl (methyl 2-benzimidazole carbamate hydrochloride) or Lignasan BLP (methyl 2-benzimidazole carbamate phosphate) at 3 grams/liter, 2 liters/diameter inch. When the disease appeared to be confined to 1 or 2 limbs, a limb injection (6 grams/liter, 1 liter/diameter inch) was applied at a major crotch below the diseased limb. All infected limbs were removed as soon as possible.

Therapy was given to all infected elms with 30% or less wilt in NCR-Central from 1975 through 1977. Treated trees have been evaluated through 1979. One hundred and eighty five elms became infected during the 3 year study. Ninety eight (53%), exhibited 30% or less wilt at the time of detection and received therapy. As of 1979, 57 of the treated trees are standing with no evidence of a DED recurrence. Treatment has been most successful on trees with minor local infections.

Therapeutic treatment is now a routine component of the NCR-Central DED management program.

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TOWARDS ENERGY SELF-SUFFICIENCY: THE LOWELL APPROACH

DULLEA, MARK

This paper deals with the development of an energy plan for a small national historical park in an urban core setting. The Lowell National Historical Park is based upon that city's preeminence in the Industrial Revolution in North America, a position attained due to the great amount of energy supplied by the Merrimack River's descent of over thirty feet in the distance of less than a mile. The plan seeks to evaluate all types of renewable energy sources available at or close to individual Park buildings. Energy conversion equipment required must be capable of being integrated unobtrusively with the Park area's historic structures and sites.

Early in the planning study it is necessary to determine as closely as possible the energy needs of the Park, including transportation needs of visitors and Park personnel, space heating and cooling of buildings to be operated by the Park Service and Lowell Historic Preservation Commission, domestic hot water use, and electrical energy. Energy supplies will be determined from all available sources, including hydropower, solar thermal and photovoltaic energy, and wind energy. Any opportunities within the boundaries of the Park and Preservation District to derive useful energy from cogeneration and waste materials conversion technologies are also to be sought out.

Other aspects of the undertaking are concerned with the economics of various energy conservation and development scenarios, jurisdictional conflicts, and the creation of energy-related interpretive measures.

Lowell offers the opportunity to demonstrate ways in which the combining of energy conservation techniques with locally-available energy sources can be achieved in the urban context, including under conditions where the protection of historic features is a prerequisite. By carefully determining future energy needs and by meeting these needs locally to the maximum extent possible, energy self-sufficiency can be approached and possibly achieved, even under difficult circumstances.

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USE OF ELECTRICAL RESISTANCE AS A MEASURE OF VIGOR IN WHITE PINE

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The Lyndon Baines Johnson Memorial Grove, on Columbia Island, Washington, D.C. was planted in 1975 with over 900 white pines (Pinus strobus L.), 4 to 6 meters in height, averaging 11 years old with an 11 cm diameter (dbh). Since transplanting there has been a demise of trees in the poorly drained eastern portion. Trees in the western portion, which was originally forested river dredgings, are more vigorous.

In 1978 a study was initiated to determine if electrical resistance measurements (ER) of cambial tissue could be used as a practical, reliable parameter in determining white pine vigor. Trees were rated by visual characterization based on form, color, and density and divided into four classes of 25 trees each. ER measurements were taken with a field ohmmeter and compared with other growth parameters; needle length, needle retention, internode length, and growth ring measurements. ER readings were taken in August and September, 1978 and May and July, 1979. September, 1978 measurements exhibited the widest ER range and best class delineation. ER measurements for class IV trees (most vigorous) was 5,500 KΩ; class III, 6,100 KΩ; class II, 7,200 KΩ; and class I, 10,000 KΩ. August, 1978, and May and July, 1979, ER measurements were generally higher, within a narrower range, and did not separate vigor classes as well as September, 1978 readings.

Growth ring measurements for each class (3.0, 5.2, 7.1, and 10.0 mm for classes I through IV respectively) correlated closely with ER measurements. Prior to transplanting all trees were growing at similar, uniform rates and could not be separated into classes. Growth rates dropped precipitously after transplanting and only reached pretransplant levels in class IV trees. Needle length and internode length also correlated with vigor.

Season, condition of the bark, and injury or decay affect ER measurements. All visual classes can be distinguished by ER measurements. Although growth ring measurements are considered to be a reliable parameter for determining tree vigor, the technique is laborious and time consuming. The use of visual classification and ER measurements is a reliable and rapid method for vigor assessment in white pine. This technique can be used in management of a large single species planting for selection of trees for removal and replacement.

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AN ASSOCIATION OF BACTERIA WITH SHADE TREE LEAF SCORCH IN THE NATIONAL CAPITAL REGION.

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Leaf scorch is a mid-summer disorder which affects many American elms, red oaks, and sycamores within the urban parks of the NCR. Elm leaf scorch appears as an undulating marginal necrosis preceded by a chlorotic halo. Symptoms progress in severity from younger to older leaves. Severely scorched leaves curl upwards and abscise early resulting in bare branches with tufts of mildly scorched or green leaves at the tip. Scorched leaves may appear on a single limb or throughout the tree.

Similar symptoms appear on red oaks and sycamores. Leaves develop a marginal and intervinal necrosis culminating in total necrosis and premature abscission. Leaf scorch is not lethal, but is associated with dieback resulting in disfiguration of specimen trees.

Ultrathin sections of scorched leaves from 14 elms, 7 red oaks, 5 sycamores, and symptomless trees were examined by transmission electron microscopy.

Bacteria were consistently observed filling or scattered throughout the lumina of the smaller tracheary elements of primary and secondary veins of scorched elm leaves. No bacteria were found in tissue from symptomless control leaves. Bacteria were rod-shaped, 0.3-0.4µm X 0.9-2.4µm, with thick (35nm) multi-layered, rippled, cell walls. Microfibrils (fimbriae) were occasionally observed extending from the wall. Bacteria occurred in a slime-like matrix surrounded by a translucent halo.

In the longitudinal sections the bacteria-matrix complex filled the ends of the vessel elements and pit cavities. Small, densely staining spindal-shaped bodies, with rippled walls, possibly degenerate forms of the bacteria, were seen within a matrix appressed against the wall or filling the lumina of tracheary elements. Similar bacteria and spindal-shaped bodies were consistently found in the tracheary elements of scorched red oak and sycamore leaves. Oak and sycamore bacteria were slightly shorter than those observed in elm and were surrounded by numerous microfibrils.

The bacteria observed in all three species resemble rickettsialike bacteria found in Pierce's disease of grape, almond leaf scorch, alfalfa dwarf, peach phony, plum leaf scald, citrus blight, and periwinkle wilt.

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SUCCESSFUL PLANTING OF AN URBAN PARK

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The manipulations necessary to bring about a successful planting at Constitution Gardens, a 42 acre park in Washington, D.C., provide prototype experiences, some of which might well be applied to other appropriate situations in our park system. Many of the actions taken were designed to reduce maintenance requirements.

There are several phases through which planting projects should proceed:

1. Establishment of purpose and nature of the project through preliminary planning by the park.
2. Design and review.
3. Establishment of strong contracts and work orders.
4. Planting and post-planting actions.

This report will deal primarily with the post-planting aspect of the fourth phase of the Constitution Garden project.

The Parkscape was created in just two years from the site of the Navy Administration since World War II to the informally designed urban park for the Bicentennial dedication. Previous work by James Patterson defined the efforts to create a vital soil for the site.

To better study areas of poor plant survivability, the park was divided into four planting areas:

1. Walking trees, 2. open space trees and shrubs, 3. azalea beds, and 4. turf.

The survivability of original plant materials by species was analyzed in these areas. Wherever possible, specific recommendations were made and actions taken to correct on-site conditions or improve selection of plant materials where survivability was low.

A different sort of problem arose during the spring of 1979 when a serious algae bloom arose following turf fertilization. This situation, too, has been righted and is being controlled through introduction of a designed biological regime in conjunction with nigrosine dye.

Over the long run, energy and maintenance dollars will be saved through practices which tend to insure longer lived, vigorous plants. Site engineering efforts may be necessary, but maximum success for the dollar can be achieved through selection of the proper plant materials for the site.

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EVALUATION OF COMPOSTING TECHNIQUES TO TREAT HUMAN WASTES AT CAMPSITES ALONG THE APPALACHIAN NATIONAL SCENIC TRAIL

SPENCER, EDWARD L. - ELY, JENNIFER F.

Adequate treatment of human wastes at remote sites in parks poses a serious problem. Small amounts of raw wastes have the potential of polluting surface waters and water supplies. Composting techniques present a potential solution. Mixing raw wastes with shredded bark chips in an enclosed container creates a suitable environment for mesothermic bacteria and advanced biological activity. Elevation of pile temperatures and bacterial competition transforms the wastes into an aesthetically agreeable endproduct and eliminates pathogens. Two composting techniques have been tested and evaluated along the Appalachian Trail in New Hampshire and Maine. The design, results and management implications of this technique are reported here.

Two experimental designs were evaluated, a bin composter and a solar assisted continuous composting unit, specially designed for this study. The bin composter is a fiberglassed box 4' x 3' x 2½' with air circulation tubes and a removable fiberglass top. Seventy gallons of wastes are thoroughly mixed with about 500 pounds of shredded hardwood bark. The mixture is placed in the composter and monitored to assure that the pile temperature exceeds 125°F. It is then remixed, a second temperature maximum is attained and the cycle is complete. The bark can then be recycled to compost additional wastes. A composting cycle takes two to three weeks.

The continuous composter is of commercial design. Because of the severe mountain climate a passive solar panel and heat storage unit was designed into the unit to buffer the compost pile from low temperature extremes in the summer and to improve evaporation rates of liquids. Composting in this mode is much slower and the temperatures are lower. There is no requirement for handling of raw wastes, however.

Aerobic composting depends on correct pH levels and moisture levels. The pH levels were between 5.5 and 7.5. The mixture is usually well buffered and significant variation does not often occur. Moisture levels were between 40 and 56% liquid. Bin units showed temperatures as high as 167°F, while the continuous composters were usually several degrees above ambient. Capital costs were $1004.00 for the bin composters and $3375.00 for the continuous units. Annual operating costs for the bin were $221.00; for the continuous units they were $87.00. Both managers' and users' evaluations were positive.

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MODIFICATION OF THE BELTSVILLE METHOD OF COMPOSTING FOR LOCAL SITUATIONS

SIKORA, L. J., WILLSON, G. B., AND PARR, J. F.

The Beltsville Method of Composting was developed as an economical process for converting sewage sludge into a soil conditioner-low analysis fertilizer that is acceptable for use in urban areas. Experience with the process indicates that it is adaptable to a wide range of applications. Although most of the research has been conducted with woodchips for the bulking agent, a number of materials that may be available in other locations have been tested. Alternative bulking agents found suitable for composting have been corn fodder, shredded paper, paper pellets, unscreened woodchip compost, unscreened paper pellet compost, tree trimmings, sawdust, and peanut hulls. Choice of bulking agent is based on availability, cost, and final use of the product.

The effect of other local design requirements on the process such as volumes of materials to be handled, climate, and waste characteristics will also be discussed.

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RAW WASTE RECYCLING THROUGH STATIC PILE COMPOSTING

PATTERSON, JAMES C. AND SHORT, JOHN R.

Economical treatment of human wastes through conventional treatment systems, particularly in relatively inaccessible areas of the country, may become increasingly difficult to achieve. Concern with possible environmental degradation along the Chesapeake and Ohio Canal National Historical Park led the National Park Service to review alternate methods of sewage treatment. The static pile composting system was chosen to replace previous methods of sewage treatment because of its low intitial and operating costs, low energy requirements, possibilities for future organic waste recycling, and production of a stable, useful final product. Initial success with this method of waste treatment prompted this study in cooperation with the U.S. Environmental Protection Agency, in which composting of septic tank waste and sanitary toilet waste was evaluated to determine the feasibility of composting as a waste recycling method.

Results of the composting system were evaluated in terms of pathogen destruction, nutrient content, and metal pollution. Analysis of the compost indicated that static pile composting is an effective method of waste treatment. Effective pathogen destruction is achieved at pile temperatures above 55 C for approximately one week. Nutrient analyses indicate that the compost may be used as a low analysis fertilizer, with nitrogen contents of about 1.0%, phosphorus contents of about 0.3%, and potassium contents of about 3.0%. Metal pollution did not appear to be serious, because of the domestic nature of the wastes composted.

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USE OF SEWAGE SLUDGE COMPOST IN THE VEGETATION OF URBAN LANDS

MURRAY, JACK J.,* HORNICK, SHARON B.,* PATTERSON, JAMES C.**

Efforts by the U.S. Department of Agriculture at Beltsville, Maryland, have developed a method for composting urban sewage sludge and woodchips. This Aerated Pile Method of composting yields a stabilized product that can be used beneficially as a soil conditioner and as a source of plant nutrients. The humus-like material is essentially odorless and pathogen free and very low in metals that may be toxic to humans or plants.

This sludge compost improves soil physical properties, as evidenced by enhanced aggregation, increased soil aeration, lower bulk density, less surface crusting, and increased water infiltration, water content and water retention. Research has shown that the compost produced from the District of Columbia sludge can be safely used as a fertilizer or soil conditioner where food chain, root, and leafy vegetable crops are grown. This compost can also be used as a topsoil substitute for land reclamation and public works projects, for production of turfgrasses, for nursery production of trees and ornamental plants, on golf courses and cemeteries, for revegetation of disturbed lands, and for landscaping the grounds of parks and public buildings.

Much of the parkland in Washington, D.C. area is grass-covered and receives heavy use by visitors, local residents and government employees. The National Capital Region (NCR) of the National Park Service has taken advantage of the ability of urban sludge compost to improve soil physical properties. Over the last six years, the NCR has used in excess of 100,000 cubic yards in vegetation efforts in various project areas and numerous parks. The NCR has also utilized the Aerated Pile Method of composting to convert the raw waste from sanitary facilities into a fertilizer product. The USDA and NCR have also experimented with other wastes such as horse manure, paper and leaves. Successful applications of these materials have been made to picnic areas, ball fields, trails, and other urban areas.

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SOIL PROPERTIES OF THE MALL IN WASHINGTON, D.C.

SHORT, JOHN R.,* FOSS, J.E.** AND PATTERSON, J.C.*

The Mall is a formal park located in Washington, D.C. between the Capitol and the Washington Monument. The National Park Service has a vital interest in maintaining the highest quality turf and elm tree stands possible in this centrally located area. Previously, only sketchy data had been available regarding soil conditions in this important area. This research project was undertaken to provide detailed soil information, and to facilitate maintenance of high quality turf and elm tree populations.

Historically, the Mall was a marsh which was subsequently filled through dredging and construction activities. The Mall has remained relatively stable for approximately one hundred years, with only minor surficial soil changes occurring. Some natural pedogenic soil development has appeared to have occurred, although the soils remain very heterogeneous. The soils are relatively dense when compared to natural soils, and there is a lower amount of organic matter in the surface horizons of these soils. Artifacts, indicative of human activities, are present in these soils.

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AN EVALUATION OF URBAN GARDEN SOIL, VEGETATION, AND SOIL AMMENDMENTS

HORNICK, SHARON B.,** PATTERSON, JAMES C.,* CHANEY, RUFUS L.**

Gardening has become a popular activity for the urban resident. Abandoned lots, old building sites and portions of intra-city parks have become garden sites. Data recently published from Boston, Baltimore, the USDA, and other urban locations has brought to light some possible areas of concern with regard to urban soil quality and eventual plant uptake from these soils. Of particular concern is the heavy metal content of soils. Sources of problems cited are roadside locations where lead becomes a problem, abandoned building sites where lead paints have been used, and other sources such as air-borne or soil-borne problems relating to industry.

An evaluation program was undertaken during the summer of 1979 to evaluate the soil chemistry of the gardens on National Capital Region (NCR) lands. 1978 data from National Park Service gardens in Washington has indicated soil lead levels as follows: median 163 ppm, maximum 773ppm; the USDA data for Baltimore indicated a median of 800ppm while the maximum was 10,000ppm. Random soil and plant samples were taken from all of the NCR garden sites. At each of the fifteen garden sites random plots were chosen and the soil sampled; ten percent of the total number of gardens were sampled or approximately a hundred garden plots. From some of these plots, selected garden vegetables were sampled for their relative uptake potentials for heavy metals. The sampling of plants was based upon different garden plot management techniques and included both extremes of management.

Organic materials used at the garden sites were taken as well to evaluate this source for potential soil metal additives. This was of interest because roadside leaf composts and sewage sludge composts were used at garden locations. Control soil samples were obtained from adjacent non-affected sampling sites.

The following parameters were analyzed and will be reported upon: heavy metals - cadmium, copper, lead, nickel, and zinc; soil fertility - pH, magnesium, phosphorous, potassium, organic matter, soluble salts, and cation exchange capacity.

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STATIC PILE COMPOSTING - BACTERIOLOGICAL CONTAMINATION OF THE SOIL SOLUTION

DAVIS, RUSSELL C., PATTERSON, JAMES C., AND SHORT, JOHN R.

Static Pile Composting, a technique originally developed through the Beltsville Agricultural Research Center to compost sludge, has been adapted to accept a more liquid, human waste material found in portable toilet systems. Using this material has created additional problems other than adaptation of the structure of the pile, in that possible leaching of the waste may occur. Leaching is generally not of consequence if an impervious containment basin is used for the absorption and mixing phases of the compost operation. Commonly, the smaller scale operations would attempt composting without an impervious mixing basin. Therefore, leaching could have serious implications upon the ecological balance of nearby water systems if left unchecked.

Thus, in an effort to monitor leaching and, in effect, study the efficiency of this form of composting, the testing of fecal and total coliform bacteria is essential. This form of testing will provide conclusive evidence as to levels of bacteriological contamination within the surrounding soil solution.

Samples of the soil solution were withdrawn one day after the mixing-absorption phase of the operation was completed. Although most sampling locations would not yield any soil solution, the greatest number of samples were extracted from beneath the mixing area of the compost pod. Initial data indicates that high levels beyond the readable 0.001ml. Fecal + Total Coliform bacteria counts were found beneath the mixing site.

With the advent of widespread park usage of this composting system, this evidence must be considered before site selection is made. Ultimately, it follows that an impervious mixing-absorption basin be utilized at each compost site, irregardless of the site size.

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CONTRIBUTION OF POLYNUCLEAR AROMATIC HYDROCARBONS TO JAMAICA BAY ECOSYSTEM ATTRIBUTABLE TO MUNICIPAL WASTEWATER EFFLUENTS

SIEGER, THOMAS L.[1] and TANACREDI, JOHN T.[2]

Polynuclear aromatic hydrocarbons (PAH) are compounds consisting of two or more fused benzene rings. Despite their stability and lack of reactivity, PAH are one of the most potent and significant classes of chemical carcinogens. They are natural components of fossil fuels and there are endogenous sources of these compounds in the environment. Fossil fuel combustion and marine transport of oil have elevated the levels of these compounds in the marine environment. Because of their high molecular weight and lack of polar substituent groups, they have a low order of solubility in water and are very persistent in the marine environment. In marine systems, PAH are found associated with suspended solids and sediments and have been found to become incorporated into the tissues of marine organisms. Some researchers have suggested that elevated PAH may provide a mutagenic burden on marine ecosystems and ultimately man.

Jamaica Bay receives a large quantity of municipal wastewater effluent (300 million gallons/day), previously found to be high in petroleum hydrocarbons. Sampling of water pollution control facility (WPCF) effluents was undertaken to characterize the PAH content of the wastewater. High pressure liquid chromatography was used for sample separation together with UV-fluorescence to verify the aromatic nature of the chromatographic fractions. Analysis of surface sediments in six sites in Jamaica Bay by similar techniques confirmed contamination by substituted naphthalenes of sediments and WPCF effluents near the Coney Island and Jamaica Water Pollution Control Facilities. Numerous authors have suggested that napthalenes represent the most toxic fraction of petroleum hydrocarbons to marine organisms. Because of its aquatic toxicity, the USEPA has selected napthalene for priority attention as a point source water effluent discharge toxic pollutant. Napthalene has been listed in the "Suspected Carcinogens" list by NIOSH. Epoxides, which have been shown to exhibit mutagenic activity, are known to be formed after napthalene metabolish. Data in this study has exhibited quantities approaching 10 metric tons of napthalens entering Jamaica Bay annually by way of treated wastewater effluents.

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PREDATION, A MAJOR CO-FACTOR TO CHLORINE POLLUTION FOR ECOLOGICAL DISRUPTION IN THE UPPER POTOMAC AND ANACOSTIA ESTUARIES AND ENVIRONMENTAL GUIDELINES FOR CONTROL OF PROBLEM.

WESTER, HORACE V., WATKINS, CHARLES H., AND DAVIS, RUSSELL C.

Previous research by this laboratory reported a recent major ecological disruption had occurred in the upper Potomac and Anacostia estuaries. This study identified chlorine pollution as a factor. Further studies have identified predation as a co-factor of the problem. Control of chlorine pollution can be expected to lessen the effects of predation.

Three power plants, 6 sewage treatment plants, and the Georgetown water reservoir represent the main point sources of chlorine pollution in this ecosystem.

Scheduled strategies for reducing this chlorine pollution are recognized in the following set of guidelines. They consider the environment, yet do not materially affect the use of chlorine for power and sewage plants or reservoir maintenance.

Discharges by power plants

Schedule intermittent treatment of cooling water as follows:

1. Schedule treatments only during maximum hour of ebb tides.
2. Apply treatments only for 2 intermittent 15 minute periods for each maximum ebb tide per day as conditions require.
3. Residual levels of chlorine in cooling water not to exceed following seasonal levels for temperature conditions.

March thru May 0.05 - 0.1mg/l
June thru August 0.1 - 0.2mg/l

Discharges by sewage plants

Schedule continuous treatment of effluent at 0.2 - 1.0 mg/l residual chlorine for summer recreational period, May thru September.

Discharges by Georgetown Reservoir

Schedule discharges, required for occasional sediment removal, preferably during "winter" season, November 15 - March 15, when chlorine pollution is likely to be least from other sources.

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PLANT AND ANIMAL DIVERSIFICATION IN AN URBAN PARK THROUGH THE DEVELOPMENT OF MEADOWS

Fleming, Peggy

With the objective of diversifying plant and animal life in Rock Creek Park, since 1977 a number of meadow areas of grasses and wildflowers have been developed. Previously only mowed lawn and mature second growth deciduous forest were the major vegetative types. This paper is an interim report on the progress and resultant changes in the plant and animal life.

The Meadows Program is founded on the concept that greater diversity in plant and animal life has multiple benefits for the Park and Park visitors. The Program complements the objective of managing the Park in a natural state. Diverse vegetative types mean additional educational opportunities for Park interpreters as well as more variety for those visitors interested in natural history.

Rock Creek Park, a national park in Washington, D.C. has approximately 2200 acres, over 85% of which is in forest. The remainder is in lawn (golf course, playing fields, picnic areas) and in pavement (parking, tennis courts, streets). The choices for meadow sites were limited due to the intense recreational use of the Park. As a result the meadow sites in the Park are small. Typically they are long and narrow, having been carved from lawn areas adjacent to the woods. Meadows were produced by simply letting the lawn grow. Out of thirteen meadow sites (fifteen acres), six are research meadows which are being monitored to determine botanical and zoological changes focusing on vegetation, birds and butterflies.

Preliminary conclusions are that meadows provide added diversity in plant and animal life. Winter and summer birds which had not previously been recorded have been seen. Thirty-nine species of butterflies were found in the second year of meadow growth. Since most of the meadows had been thriving lawn (seeded, limed, fertilized and mowed) lawn grasses still predominate. Wildflowers are becoming more evident and several methods are being tested for increasing their presence. The Meadow Program is a small project in a small park. Even on this scale however there is an increase in plants and animals. The potential for expanding biological variety in any park through a program of this type appears substantial.

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TO BUILD A MARSH

SIEGEL, LOU, SILVERSTEIN, HAROLD, GAY, BONNIE LOU*

Forty five minutes from Broadway there exists an ecosystem under stress. Plum Beach, Brooklyn part of the Jamaica Bay Unit of Gateway National Recreation Area consists of a mudflat-saltmarsh-dune ecosystem. The area is stressed in three ways: it receives sufficient amounts of raw and partially treated effluent to be closed to swimming; currents and wave action have caused considerable erosion which endangers the man-made foot and bike paths as well as the nearby, heavily traveled highway; destruction of the natural areas are resulting from the heavy visitor usage of the area which includes cars parked on the dunes. The project was designed to increase the area of intertidal marsh (Spartina alterniflora,) under the hypothesis that the Spartina would provide a protective region which would reverse the flow of sand resulting in an accretion along the beach face. In addition the new marsh area would protect the dunes improving the profile along the upper beach. Less obvious benefits would also be derived by the uptake of nitrates and phosphates from the water, the decrease in turbidity, and the suitable area for the growth of many invertebrate and vertebrate species. Three methods of planting were utilized: seeds, laboratory grown seedlings and natural culms. The planting was carried out by the marine biology students at John Dewey High School after an extensive curriculum including estuarine ecology. Sign posts were placed on the beach face to inform the public of the purpose of the experiment and the importance of the marshes. The rangers stationed at the beach have produced materials and programs with the same aim. All methods have been successful. Multiple transects, perpendicular to the high tide line, have been taken to establish a base line against which future measurements can be compared.

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TRANSPLANTING THE VALUABLE MARSH GRASS SPARTINA ALTERNIFLORA IN AN ENVIRONMENTALLY STRESSED AREA

GAY, BONNIELOU[1] and ENRICO, JOSEPH[2]

Plumb Beach is a small portion within the Jamaica Bay Unit of Gateway National Recreation Area. Its 150 acre tidal marsh system is among the few of these valuable areas left in New York. To the east of the visitors' station exists established upland, dune, marsh-lagoon and inter-tidal mudflat ecosystems. To the west lies a highly eroded barren beach and crumpled bicycle path. Steep sand cliffs along with only 104 feet distance between the high tide mark and a major highway system suggests a troubled beach.

Marsh grass transplants in the form of single-stem plants and small sections of independent marsh brought to the area in storm conditions were used. A shallow breakwater of rock was constructed to absorb the impact of bounding waves. Single-stem plants were measured and sorted according to developmental stages. Transplants were placed equidistant from one another 12" apart in the protective plot which started at the base of the high tide line extending seaward. Methods used were those of Woodhouse, Seneca and Broome in Technical Memorandum #46 entitled "Propagation of Spartina alterniflora for substate Stabilization and Salt Marsh development."

Small marsh sections were dug in (as opposed to being placed) also within the eroded section. No protective barrier was created for them. Several interdependent factors were studied: size variance and developmental stage of transplants; the different locations from which they were extracted; and the actual survival and propagation ability.

The long-term success of this project (i.e. to prevent erosion) is still undetermined. However, the success of propagating Spartina alterniflora to the stressed waters of Jamaica Bay once again allows nature to take its course with a little help from man.

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ENVIRONMENTAL EDUCATION

HUNTING LIVE DINOSAURS IN GRAND CANYON IN 1937: ON THE ROLE OF THE POPULAR PRESS AND THE ADVANCEMENT OF SCIENCE

McGRAW, DONALD J

The study documents the American Museum of Natural History's 1937 expedition to Shiva Temple, an isolated mesa within Grand Canyon, which sought to inventory the zoogeography of the landform. Irresponsible news reporting by radio and newspaper writers came near to making a mockery of a simple biotic survey. Reports of a live dinosaur hunt were rampant and led to a number of unnecessarily exciting and misleading news articles nationwide. The actual zoological findings were of minimal significance.

In 1935 it came to the attention of Dr. Harold E. Anthony, curator of mammals at the Museum, that some blanks still existed on the Museum's zoogeographic map of North America. That herculean mapping project required as full documentation of animal range boundaries as possible on the map of the U.S. and Canada. This was particularly true for mammals, Anthony's specialty. The curator did not have direct interests in reptile distribution, let alone that of extinct dinosaurians.

The zealous interest of several reporters, but especially flamboyant Robert J. Casey of the Chicago Daily News, caused a considerable misrepresentation of the intended goals of the expedition. In an ever-growing and continually more misdirected series of articles, it became very "apparent" to newsmen and readers (and radio listeners) alike, that the expedition was exploring the possibility that living dinosaurs might still be found on isolated Shiva Temple.

Casey was one of America's most well-known reporters during the early twentieth century. His style was often emotional and evocative. He had the knack of touching the adventuresome bent in the America psyche. He had to say of the expedition that Anthony had "late today radioed back that he had found unmistakeable evidence of animal life atop the mysterious 'Island in the Sky' of the Grand Canyon." That evidence was merely rabbit spat. Many other similarly evocative stories came from his typewriter. The problem of sober science versus the popular press is examined in this historical study.

Sequoia Kings Canyon
National Parks, CA

MY DOME, SWEET DOME: GEODESIC GREENHOUSES WITH AN INTERPRETIVE CONNECTION

TANACREDI, JOHN T. and KENNETH DAVIES*

Environmental education at Gateway NRA involves two prototype geodesic domes. Modeled after a single dome constructed in the "FUSES" program at Fordham University, the domes have been a source of information concerning geodesic construction, French-intensive horticulture techniques, aquaculture, solar energy principles and energy conservation. The Gateway Geodesic Greenhouse System provides a unique "interpretive connection" between the physical, natural, and engineering sciences, while emphasizing three themes: First, to apply "appropriate technology" to build "smaller," more energy efficient structures with relatively little costs involved, and as E. F. Schumacher expressed, to bring the "human factor" back into urbanized environments. Second, fossil fuel subsidized agricultural systems are basically inefficient at producing food supplies. Natural energy subsidized systems maximize efficiency providing an advantage to eating lower on the food chain. Third, cooperative activities in environmental education call for "interpretive networks" enabling us to stretch our resources and work toward common goals.

The domes are covered with clear polyethylene plastic and filled with fiberglass insulation to conserve energy and to keep temperatures at a biologically acceptable level year-round. Raised beds in the domes follows the French-intensive method described by Duane Newcomb in "Organic Gardening and Farming." Horse manure and aquaculture wastes provide enrichment of the soils. An "enclosed" system with a passive solar collecting ability, all techniques used are manageable by the "general public" with use of recyclable materials. A variety of physical and chemical parameters associated with the aquaculture systems will be conducted. Variations in planktonic food sources will be monitored to determine optimum yield of fish species.

There are presently four such domes in New York City. The suitability of this system for urban environments, as well as the emphasis of an application of such an appropriate technology to city dwellers is the main purpose of this system.

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A SENSORY APPROACH TO SALT MARSH EDUCATION

PHILLIPS, JEANNETTE H.

To gain increased acceptance, environmental education must offer immediate, personal experiences. It must involve people in the natural cycles around them, giving them a sense of how their own actions affect other forms of life. The NOAA-funded National Estuarine Sanctuary Program aims to preserve portions of America's undeveloped estuarine coast to increase public appreciation of estuarine ecosystems. Sapelo Island National Estuarine Sanctuary at Sapelo Island, Georgia, stresses salt marsh interpretation. Until recently, this interpretation was visually-oriented. A broader approach is now used to sharpen human sensory responses to the moods and cycles of marsh life.

Sapelo's estuarine sanctuary is dominated by salt marsh - - the marsh that creates a quality of life so appealing to residents of coastal Georgia. This marsh nurtures commercially important finfish and shellfish, cleanses waste water, buffers the high ground from storms and population encroachment, and shelters many creatures. To understand the life within a marsh is to revere it; yet many who reap the rewards of this intricate system have no knowledge of its workings. Public education conducted by estuarine sanctuary staff emphasizes the many sensory elements of salt marshes.

Most peoples' strongest impressions are visual ones. If the vision is untrained, these impressions are random and incomplete. Marsh visitors can be enticed to focus on specific phenomena, such as soil color and variation in plant height, as keys to understanding marsh ecology. Eyes closed, people can hear many sounds in an undisturbed marsh. The click of fiddler crab claws, wind and water noise, and bird cries are easily perceived by the alert ear. Salt marsh visitors are often struck by the distinctive sulfur odor. They don't usually understand why the marsh exudes this fragrance, so they don't like it and tend to ignore it. Yet the odor reveals an essential fact of salt marsh ecology and provides an effective cue for the interpreter. The marsh teems with plants and animals to be touched. Tactile sensations range from the tiny pinch of the fiddler crab to the sharp point of the black needle rush shoot. The taste of a salt marsh is definitely salty: people can experience it by tasting a smooth cordgrass leaf, chewing on a piece of succulent saltwort, or sampling drops of saline tidal water.

An objective of the Sapelo Island National Estuarine Sanctuary public education program is to help people appreciate the wetlands by employing all their sensory mechanisms to observe. By using all these means of perception, the visitor leaves the marsh with a multitude of experiences upon which to build a foundation for understanding the system.

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ENVIRONMENTAL EDUCATION IN SAPELO ISLAND NATIONAL ESTUARINE SANCTUARY

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At present, 50% of the U.S. population lives within 50 miles of its coasts. By the year 2000, demographers say this figure will reach 75%. This trend means increasing pressure will be placed on our coastal resources. To protect these resources from disruption, misguided exploitation and possible extinction, we must educate the public about coastal ecosystems and man's place in these systems.

To help answer this need, National Oceanic and Atmospheric Administration, Office of Coastal Zone Management, in 1975, created the National Estuarine Sanctuary Program with three main objectives: 1) to protect relatively unspoiled estuarine areas for posterity; 2) to serve as controls against which to assess changes in developing coastal watershed areas; and 3) to provide a focal point around which to educate the public about the importance of coastal systems. OCZM has thus far provided 50-50 funding for five estuarine sanctuaries. Sapelo Island National Estuarine Sanctuary, at Sapelo Island, Georgia, was the second designated. Administered by Georgia Department of Natural Resources, Coastal Resources Division, the Sanctuary's environmental education program focuses mainly on coastal wetlands and the sand sharing system.

Education efforts for the general public coexist with basic research conducted by the Sapelo-based University of Georgia Marine Institute. Their research program pioneered in salt marsh productivity studies that emphasize the critical relationship between healthy marshes and Georgia's commercial fishing industry. Coordinative efforts between Sanctuary and UGMI staff interpret current Marine Institute studies for Sanctuary visitors. A similar arrangement exists between Sanctuary personnel and Department of Natural Resources' Game and Fish Division staff, who manage the Sapelo Island R. J. Reynolds Wildlife Refuge.

To accommodate young people, who will make future decisions concerning wise use of coastal resources, Sanctuary trips are activity-oriented. Marsh treasure hunts and construction of food webs with colored yarn are two examples of numerous learning tools employed to involve youngsters physically. Environmental education must make sense to people; strategies must be developed to appeal to all age levels.

The overall mission of the Sapelo Island National Estuarine Sanctuary Program, is to acquaint as many people as possible with coastal ecology. Often this involves tempting people to take small but increasingly confident steps into a field they thought reserved for scientists. The goal of the Sapelo Island National Estuarine Sanctuary public information effort is to help visitors learn about their complex environment and then participate in planning for its wise use.

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ENVIRONMENTAL EDUCATION AND RESEARCH OPPORTUNITIES ON THE GEORGIA COAST

SAVELAND, ROBERT N.

The Georgia coast is an area having exceptional opportunities for environmental education and research. The line of barrier islands and extensive marshlands have been uniquely preserved as a result of several factors including strong tidal currents, inaccessibility, landholdings in private estates of wealthy individuals, and, more recently, protective legislation.

Only three of the barrier islands, Tybee, St. Simmons and Jekyll have been intensively developed. Wildlife refuges are found on Wassaw, Blackbeard, Harris Neck, and Wolf islands. Major on-going programs include the University of Georgia's Marine Extention Service at Brunswick, the Sea Grant Program at Skidaway, and the Marine Research Institute on Sapelo. The Georgia Department of Natural Resources also operates an educational program on Sapelo. Many young persons have been involved with Project Genesis on Ossabaw. Through the interpretive services of the National Park Services, the general public is gaining an awareness of the nature of this coast by visiting Cumberland Island National Seashore.

While the goals of the various institutions and agencies involved in environmental education and research may differ in degree, they contribute to the common aim of enhancing our knowledge of this exceptional ecosystem and how it functions. The Oatland Island Education Center operated by the Chatham County Schools is another example of this process.

The situation at all these centers of activity is not static. All face recurring funding problems. Growth is taking place, as on Cumberland Island where daily visitor attendance continues to climb.

The range of topics for research investigations in this environment is limitless. These range from scientific investigations of water quality and fish populations to studies of the effect of olefactory pollution on the quality of the recreational experience on Cumberland Island. With expanding population in the southeast and changing lifestyles, the environmental education and research activities on this coast will assume increasing significance.

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INFORMATION SCIENCES

THE IMPORTANCE OF VEGETATION MAPPING FOR MANAGING PARK SERVICE NATURAL RESOURCES

MOUAT, DAVID A.* and R. ROY JOHNSON**

Vegetation maps are essential for National Park Service resource managers. As they provide an index to the environment, these maps can be used to solve many problems. Among these are controversies involving wildlife and livestock management, visitor use impact, and fire management. Without proper baseline data, Park Service resource management will continue to have problems with "brush-fire" controversies.

The need for appropriate vegetation mapping for resource management is well illustrated through requirements of the National Park Service. While it is one of the major geographical features of the earth's surface, vegetation is too often ignored in management considerations. The resource manager faces a variety of demands regarding land use. In many cases, the uses are complimentary; in others, they are conflicting. Disturbances in the ecosystem are often readily recognized by changes in the structure and species composition of the vegetation. The understanding of vegetation, then, is of paramount importance to the resource manager.

Information on vegetation needs to be oriented toward ultimate management use. A number of factors must be considered by the resource management user as well as by the vegetation mapper. Scale and classification systems are extremely important. Vegetation type mapping symbols, descriptions, and management interpretations must be readily understood by the ultimate user. A hierarchically-based classification system is preferred as it allows for mapping through remote sensing techniques and for the delineation and the typing of units in less accessible areas.

The final vegetation map, if properly constructed, can be used for a variety of purposes. Wildlife and livestock management is based upon up-to-date baseline information including vegetation. Many of the past mistakes in wildlife and livestock management have occurred through ineffective or even non-existent habitat information. The resource manager may need to use vegetation information to assess potential visitor use impacts resulting from numerous construction activities or other management decisions. Vegetation is obviously of critical importance in fire management and in insect and parasite control. Finally, the Parks represent valuable control areas against which management of neighboring analogous areas can be compared.

Resource managers have too long asked for instant answers and "brush fire" research. Through systematic information gathering and well-organized monitoring programs (including vegetation), many of our "burro-like" controversies may be averted.

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A STRUCTURAL VEGETATION CLASSIFICATION FOR INVENTORY AND HABITAT ASSESSMENT

BUNIN, JANE AND MOIR, WILLIAM

This hierarchical vegetation classification system is designed for vegetation inventory, habitat assessment, resource allocation, or land-use planning. It is especially suitable where ecological or floristic systems are impractical, unavailable, or too expensive to use. The upper level characteristics in the classification are large-scale and discernible by remote sensing. The descriptors at or below the 3rd to 5th levels usually require ground-based data.

The classification is based upon the structure of current vegetation. The major structural characteristics used in the system include life-form types, canopy cover, leaf shape and persistence, and height of the vegetation. Current vegetation, as contrasted to potential or climax vegetation, best suits the general purposes of this system: To be an easy-to-use tool which is accessible to non-botanists and to those persons unfamiliar with local vegetation or flora, and to be a tool independent of ecological assumptions or taxonomic sophistication on the part of users.

The classification has seven initial categories: A.Closed Forest, B.Open Forest, C.Scrub, D.Dwarf Scrub, E.Herbaceous, F.Cryptogam, and G.Non-Vegetation. These categories are further subdivided by a numbers of levels which varies with the structural complexity of the category.

An example from Rocky Mountain National Park demonstrates how different scales and levels of information are easily accommodated. With a small-scale method such as aerial photography, a Colorado alpine willow community would be identified as "closed deciduous dwarf scrub". Ground reconnaissance produces more information: "closed deciduous creeping dwarf scrub with no emergents". Finally, detailed ground-based data classifies the same community as: "closed deciduous creeping dwarf scrub with no emergents, with codominant herbs, and a sparse cryptogam layer".

We would like to see the utility of this classification further tested and critiqued. How well can this structural vegetation classification meet your inventory or planning needs?

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HERBARIUM COMPUTERIZATION PROJECT

WHITE, PETER

In conjunction with resource inventory and monitoring, a project is described for the computerization of label data from the Great Smoky Mountains National Park (GRSM) Herbarium and the GRSM collections at the University of Tennessee, Western Carolina University, and the University of North Carolina. Computerization of label data of pteridophytes, gymnosperms, and monocotyledonous angiosperms has been completed (ca. 3,000 herbarium sheets and 500 taxa). The usefulness and overall cost-time budget of the system are discussed.

Processing time for each herbarium label was ca. 3 minutes, with an additional 3 - 5 minutes spent in locating the site on USGS quadrangle maps and computer coding latitude, longitude, watershed, and vegetational survey unit. Many herbarium labels are imprecise, and these sheets were coded by sets of latitude and longitude coordinates which described a box around the approximate site. Lists of plants can be produced for any sites in GRSM as defined by any combination of latitude, longitude, elevation, watershed, or other location data. A catalogue of the collections has been produced. The holdings have been analyzed for frequency of collections by years, species additions to the known flora by years of exploration, and the precision of herbarium label data. Species lists help plan future collecting; several areas in the park were discovered to be undercollected.

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VEGETATION MAP OF THE CRATER DISTRICT, HALEAKALA NATIONAL PARK

WHITEAKER, LOUIS D.

A large scale vegetation map of the Crater District of Haleakala National Park was produced at a scale of 1:24,000 which overlays a composite of the USGS quadrangle maps that cover the same area. Mapping was conducted on aerial photographs, and boundaries were checked in the field. Vegetation units were sampled using relevés (sample quadrats); 42 structural-floristic vegetation units were recognized, belonging to four general structural types. A synthesis table analysis and dendrograph analysis of the relevé data that was generated on the computer support the mapped units and provide additional floristic information on these units.

The vegetation units were found to be related to a complex of temperature, precipitation, and edaphic factors. These relationships are illustrated by three profile diagrams and climate diagrams for five sites. Also, it was noted that distribution and composition of the native vegetation units is strongly affected by feral goat and pig populations and the introduction of exotic species by feral and domestic animals and by man.

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THE INDIAN PEAKS ENVIRONMENTAL ATLAS, COLORADO FRONT RANGE

IVES,J.D.; BAUMGARTNER,R.; PLAM,M.; BURNS,S.; DOW,V.; HANSEN,K.; KETCHIN,A.; LUFF,D.; MC CORD,B.

President Carter established the Indian Peaks Wilderness Area in November 1978. Occupying the land along the Continental Divide immediately south of Rocky Mountain National Park, its future long-range management by either the U.S. Forest Service or the National Parks Service is presently under discussion. Additional components of the Indian Peaks section of the Front Range are the Niwot Ridge Biosphere Researve (established by Unesco, May, 1979) and the City of Boulder Watershed; the latter is closed to the public.

For the past two years the Institute of Arctic and Alpine Research, through its Mountain Research Station, has been involved in the production of an environmental atlas of this mountainous area comprising the three different management units described above. The work is supported by NASA-PY Grant No. NGL-06-003-200. The objectives of the Atlas will be discussed in some detail since we hope that it will become a prototype for input into the development of management policies for Wilderness Areas, Parks, Biosphere Reserves, and other mountain areas. Specific objectives include: a) development of methods for air photograph interpretation of high mountain physical resources b) mountain landscape analysis from both physical and human behavioral points of view c) study of human impacts on mountain wilderness areas d) contribution to scientific knowledge and methodology of complex and rugged terrain e) development of a set of recommendations for the management of such areas f) general public education.

Specific thematic maps, compiled at 1:24,000 for publication at 1:50,000 include: soils, vegetation, glacial deposits and geomorphology, landscape types, natural hazards including avalanches, ecological land classification, and human impacts and use patterns. The maps with accompanying text and copious graphic materials should not only provide a vital document for development of land-management policies in the Colorado Rocky Mountains, but through its conceptual approach, involving a holistic analysis, will be applicable to other types of mountain environments.

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VEGETATION MAPPING AT GRAND CANYON NATIONAL PARK: AN ANALYSIS OF TECHNIQUES

MOUAT, DAVID A., B. KIM MORTENSEN, KAREN L. REICHHARDT, PETER L. WARREN

The vegetation of Grand Canyon National Park is being mapped as a cooperative project between the University of Arizona and the National Park Service. A refinement of existing techniques to fit the vegetation and lack of terrain accessibility has been found to be necessary. Key elements of the methodology have involved the production of an appropriate and flexible classification system, remote sensing techniques, and carefully defined field procedures.

Grand Canyon National Park provides an excellent locality to test the flexibility and general utility of vegetation mapping techniques on account of the tremendous variation in vegetation and terrain characteristics. Within a short distance, vegetation may range from desert to boreal forest. The advantages and disadvantages of various methods of vegetation mapping procedures become readily apparent in an area of such extreme structural and floristic diversity.

The mapping methodology developed involves several major steps. Aerial photographs were obtained in both color and color-IR at 1:24,000. Preliminary delineations on the photos were made through photo-interpretation of similar image types reflecting vegetation and/or terrain variables. Data gathered at field documentation sites include a plant species list, with species ranked on the basis of estimated prominence, and environmental parameters including aspect, slope, landform and substrate. All mapping units are documented in the field. Definition of mapping units or vegetation types are based upon field data. The classification legend is expanded and modified throughout the project as new information is gathered. A hierarchical legend is best suited for vegetation classification at a small scale because of the inherent diversity of existing types. Meadows on the North Rim, for example, may have several types all occurring within fifty meters, whereas vegetation types within the forest biome may change over a gradient of several kilometers. As such, mapping techniques must take this diversity into consideration. The map scale of 1:62,500 may necessitate a combination of meadow types and a separation of forest types.

The production of a vegetation map for the entire Park requires judicious compromises between detail of vegetation delineations and map utility. The scale of 1:62,500 allows for ease of use and adaptation with existing base maps. Many of the Park's problems can only be answered through the analysis of baseline information (including vegetation) available in the entire Park at a manageable scale.

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APPLICATION OF REMOTE SENSING TECHNOLOGY TO PLANNING: A CASE STUDY

Tomrdle, Dale

Vegetation mapping of Pictured Rocks National Lakeshore, using Landsat satellite data, was begun in 1977. Though basically a research project to assess remote sensing technologies, the natural resource information gathered from the Landsat data was utilized extensively during the development of the General Management Plan for Pictured Rocks. This resource information was used to define issues and concerns ranging from road alignments and recreational developments to water resource management.

The Landsat data from bands 4, 5 and 7 was digitally enhanced and then produced as a photoproduct at the EROS Data Center in Sioux Falls, South Dakota. The 1:62,500 photo image was manually interpretted for major vegetation cover types. The Landsat image was then utilized to develop additional information required by the planning team working on the GMP.

Utilizing fifty and sixty year old soils and geologic information as a base, detailed natural resource maps were developed, using the Landsat image to modify inaccurate map units and geometrically correct mapped information. The data bases generated were then composited in various ways, depending on the specific objectives and requirements of the GMP components.

An historically proposed trans-lakeshore highway was the most visible planning issue. Minimal resource information concerning the various proposed alignments existed; the Landsat data made an accurate environmental evaluation of these road proposals possible. Similar evaluation of large recreational developments resulted in reduction in size and relocation of some facilities.

A large bog identified from the Landsat image proved to be the headwaters for two of the four major drainages in the lakeshore. The bog lies mostly outside of NPS boundaries. No decisions concerning this situation have been made at this time, but without the Landsat information the situation would likely not have come to light.

The information provided by Landsat data proved to be useful, easily obtained, and involved about ten man-weeks of time in addition to the initial data processing and photolab work.

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DENVER SERVICE CENTER REMOTE SENSING PROGRAM: EXPERIMENTAL AND OPERATIONAL

Nyquist, Maurice O.

One of the major hindrances to efficient National Park Service planning has been the lack of pertinent data. In many instances, the data are: gathered through costly contracts, out of date, inferred from secondary sources, incomplete, or out of sequence with the planning process. The use of remote sensing techniques to acquire certain natural resource data may circumvent this problem.

The Branch of Science at the Denver Service Center is involved in a program to test and demonstrate the use of various remote sensing techniques as a means of collecting basic data for planning and resources management. To meet these objectives, six demonstration projects have been initiated in cooperation with the Earth Resources Laboratory of the National Aeronautics and Space Administration (NASA/ERL) and the Earth Resources Observation System (EROS) Data Center of the U.S. Geological Survey. These projects are being performed on four different National Park Service regions and in environments with great diversity with respect to vegetation, physiography, and other natural features.

The experimental program is not complete regarding the feasibility of using computer-assisted classification of Landsat digital data. However, the experience gained from the experimental program has lead to the establishment of an operational capability to use various types of imagery for the mapping of various landcover and landuse themes. To date, operational projects have included: detailed, site specific analyses to determine feasibility of development, vegetation and other natural resource theme maps for General Management Plans and resources management programs, and broad regional mapping of landcover and landuse for the New Area and Urban Studies Program.

The use of remote sensing techniques has proven to be highly effective because of its flexibility and number of applications for use; its timeliness, accuracy, and utility of the derived data; and the low cost of the data acquisition.

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USE OF MERGED LANDSAT DIGITAL DATA IN RESOURCE MAPPING FOR PICTURED ROCKS NATIONAL LAKESHORE

STOTTLEMYER, J. ROBERT

The objectives of this analysis are to develop a vegetation cover map of Pictured Rocks National Lakeshore (PIRO) by computer analysis of merged Landsat data, determine any improvements in mapping quality resulting from the addition of digitized topographic and edaphic data, and analyze the cost effectiveness of the procedure for resource mapping.

Digital data from two passes, one in early June and one in late June, are used in the analysis to assist in discriminating among northern hardwood and conifer species types. Thematic character maps are produced using each of the data sets separately and then the data sets are geometrically corrected, scaled to 1:24,000, and merged. This merged data set is further analyzed and final geometrically corrected and scaled character maps produced.

The data encompassing PIRO and its buffer zone (totaling approximately 260 km^2) is identified and subsetted. Specialized computer programs, developed by the Office for Remote Sensing of Earth Resources at the Pennsylvania State University, are used to identify areas of spectral uniformity within the data sets and mean spectral signatures are then computed. The data is classified using these mean values and unclassified areas are analyzed by further refinement of training areas or by an unsupervised classification (clustering) approach.

Geometric distortions are removed using other programs and the data is rescaled to 1:24,000 to permit overlaying of character maps on standard maps for comparative purposes. Ground truth information in the form of color infrared 1:24,000 aerial photos flown in June 1977 and a vegetation map derived from this are used in the selection and identification of training areas and in the verification and evaluation of the computer-produced maps.

The principal product is a computer-produced character map of PIRO and its buffer zone depicting major vegetation types, lakes, and other physiographic features. The map is scaled and oriented so that it will overlay conventional 1:24,000 maps.

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REMOTE AIR AND WATER QUALITY MONITORING BY SATELLITE RETRIEVED DATA IN GREAT SMOKY MOUNTAINS NATIONAL PARK

Burge, Raymond*, Mathews, Raymond**, and Silsbee, David**

Since June 1977 four automated convertible data collection platforms have been in use in the Great Smoky Mountains National Park. These units, provided to the National Park Service by the U.S. Geological Survey EROS Program, have been undergoing field test for data validation, operational practicality, and support requirements, while at the same time producing data that have been useful to the research program of the park. Two platforms are implemented with water quality sensors which monitor temperature, conductivity, pH, oxidation reduction potential, and dissolved oxygen. The remaining two platforms are equipped with meteorological sensors which monitor cumulative precipitation, wind speed, wind direction, temperature, barometric pressure, and relative humidity. One outstanding advantage of these systems is the capability of closely spaced sampling and near realtime data retrieval which would be extremely difficult and costly to accomplish by normal field reconnaissance methods. Three of the platforms, two water quality and one weather unit, were initially deployed in the Cades Cove area on Abrams Creek, providing a comprehensive survey of water quality relative to responses caused by weather phenomena, cattle impacts, and stream flow regimes. The remaining weather unit was located at the Uplands Field Research Laboratory in the Twin Creeks area, where data generated by this system have allowed researchers to look at pH depression trends in Scratch Britches Creek in response to acid precipitation. The potential of these platforms to provide both management and theoretically orientated information to NPS scientists is continuing to be investigated. During the spring of 1979, the platforms were relocated to other areas of the park where data generated will be utilized to assess changes in water quality of watersheds having different forest growth dynamics, and to correlate weather trends with air quality data.

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DETERMINATION OF VEGETATION-HYDROPERIOD-SOIL RELATIONSHIPS IN TAYLOR SLOUGH (EVERGLADES NATIONAL PARK) AND VICINITY

OLMSTED, INGRID AND LLOYD L. LOOPE

Stability of wetland ecosystems of Everglades National Park depends upon maintenance of a naturally fluctuating hydrologic regime. Eastern Everglades National Park, encompassing the Taylor Slough watershed, is vulnerable to modifications in water flow which are already significant, but threaten to increase in the future. Baseline documentation of vegetation has been carried out and related to the environmental gradient of annual inundation (hydroperiod) and soils, utilizing a quantitative/qualitative survey-transect method.

Taylor Slough, the second largest drainage of Everglades National Park, has been modified by adjacent drainage canals constructed during the past 15 years for agricultural purposes. The reduction of hydroperiod and increased depth of drying during severe droughts have increased fire potential and destroyed plant communities and organic soil. A pumping station, presently under construction, will deliver water artificially from an adjacent canal which will increase hydroperiods locally in the Slough. The "relief" in Taylor Slough and adjoining pineland and hardwood forest varies from near mean sea level to 2-3 m above mean sea level. Mean hydroperiod at present varies from 0 to 8 months or longer. The Slough proper is dominated by graminoid marsh communities with scattered tree "islands", including bayheads, cypress forest and willow heads.

Transects were placed at intervals across the Slough, across various tree islands in the Slough, and across adjacent pinelands and tropical hardwood hammocks. Elevation and soil depth were determined and hydroperiods calculated for sampling sites characterizing plant communities. For the vegetation analysis, permanent plots were established along the transect in major communities. Plant cover, density, frequency, height and dbh were recorded and will be monitored again at regular intervals.

A similar transect survey-analysis technique is planned for all major plant communities of Everglades National Park and Big Cypress National Preserve. Being able to relate plant communities to specific hydroperiods will provide a tool for predicting what vegetation change might occur when water tables are lowered or raised. Such information will assist managers in optimizing water flows where possible and in responding to future threats to park ecosystems from drainage and development.

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RESOURCE VALUES OF THE AQUATIC AND RIPARIAN VEGETATION OF ROARING SPRINGS, GRAND CANYON

BOWERS, JAN E., R. ROY JOHNSON*, ARTHUR M. PHILLIPS, III** AND BARBARA G. PHILLIPS**

Roaring Springs is one of the major springs in Grand Canyon National Park. This large water source is of importance to the park as it supplies domestic water to both the North and South Rims. However, its primary scientific value as a water source is to the plant and animal species which it supports.

Woody species of particular interest include water birch (Betula fontinalis), red-osier dogwood (Cornus stolonifera), scarlet sumac (Rhus cf. glabra), and hop-hornbeam (Ostrya Knowltoni). A large number of sedges (Cyperaceae), juncus (Juncaceae) and other herbaceous plants also occur in the spring area. Several species are found in very few localities in Grand Canyon with some species found only at Roaring Springs. In addition to escalating demands for domestic water inside the park, ever increasing demands from outside the park threaten to decrease the water available to dependent natural ecosystems.

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PRESETTLEMENT VEGETATION OF THE INDIANA DUNES NATIONAL LAKESHORE

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The original land survey records made during 1829-1834 were used to reconstruct the presettlement vegetation characteristics of the Indiana Dunes National Lakeshore and the surrounding watershed of Lake Michigan in Indiana. A map is presented showing the distribution of the general vegetation types including savanna, forest, wet prairie, prairie, swamp, bog and marsh. These vegetation types and their topographic relationships are further refined to detail their component plant communities. A contemporary map shows the extent to which these communities remain intact today. In addition to the heavy pressures of industrialization, urbanization, and agriculture, the contemporary lack of fire has contributed to the degradation and obliteration of many of these vegetation types. The role of fire in the maintenance and restoration of presettlement vegetation is discussed.

The nature of the survey records not only permitted mapping of vegetation types, but also enabled calculation of relative density, dominance and frequency, which provided a means to further characterize wooded communities. Based on field studies, refinements were made to the vegetation map to show the occurrence of certain unique communities and features, such as pannes and interdunal ponds. These field studies enabled compilation of lists of characteristic species for all plant communities mapped. While topographic and edaphic conditions were important in governing the distribution of these plant communities, the most widespread communities, the savannas and prairies, were maintained by fire. Certain types of forest and marsh communities were also maintained by fire. Other community types, while not dependent on fire for their existence, had their distribution limited by fire. The prevailing westerly winds normally drove the fires eastward and also limited the westward extension of the mesic upland beech-maple forest. Field studies have documented the fact that many of the original communities have disappeared or have been greatly altered. Savannas and prairies, which were the most widespread during presettlement times, are now the rarest. Due to the lack of fires, savannas and prairies not destroyed by heavy development pressures, have been altered by woody invasion. Within the boundaries of the National Lakeshore, burning would be necessary if the natural communities are to be maintained or restored.

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A NATURAL RESOURCES STUDY OF CHANNEL ISLANDS NATIONAL MONUMENT, CALIFORNIA: INTRODUCTION

WOODHOUSE, CHARLES D.

In 1978 and 1979 field surveys and a literature review were undertaken to prepare a Natural Resources Study of the Channel Islands National Monument, California. Santa Barbara, Anacapa, and San Miguel Islands fall within the jurisdiction of the Monument. The goal of the study was to obtain baseline information that can be used in the preparation of a General Management Plan, in the analysis of possible impacts of management strategies, and as background for future research. The geology, soils, plants, insects, land snails, and endemic and introduced mammalian fauna are the major areas of concentration in the study.

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VEGETATION AND FLORA OF GRAND CANYON NATIONAL PARK, ARIZONA

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Bisecting the Colorado Plateau in the area where three major Southwestern deserts meet, the Grand Canyon serves as a corridor for plant species migrations and an area of intermingling of elements of diverse origin. Vertically, a difference in elevation of over 2500 m between the Colorado River and the highest elevations on the North Rim results in the occurrence of all major vegetation types from hot desert scrub to subalpine forest within a horizontal distance of 20 km.

Paleoecologically, ancient packrat middens have shown modern vegetation patterns emerging from a wetter, cooler glacial age in which forest and woodland plants occurred at lower elevations within the Canyon and, more than today, hot desert and cool woodland elements intermingled. Species responded individually to the different climatic regime, with plant communities of different species composition than those of the present. Glacial Age vegetation flourished 14,000 to 24,000 years ago; some woodland elements remained at low elevations until 8,000 years ago. In some parts of the Canyon, the post-Pleistocene upslope retreat of woodland plant species was 1,000 m.

The known flora of the Grand Canyon comprises 1527 species of vascular plants, computer listed by family, genus, species, and subtaxa with notation of abundance, threatened or endangered status, and habitat type. The woodlands and forests of the rims, and the riparian and desert areas along the river are fairly well known, but much of the rugged, remote country between the rims and the Inner Gorge remains botanically unexplored. Intensive collecting efforts in the Inner Canyon following two successive exceptionally wet winters have resulted in a number of new species records for the Park and some important range extensions. Two or three new species have been found in the past five years.

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PLANT COMMUNITIES OF ANACAPA ISLAND

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A surprisingly diverse assemblage of vegetation types occurs within the 1.1 square miles of Anacapa Island, Ventura County, California. In order to provide a basis for sound management of this portion of the Channel Islands National Monument, it was important to identify the various plant communities present and map the vegetation.

After initial field sampling to determine the vegetation types present, maps were produced using color infrared aerial photographs taken in May 1978 at a scale of 1:6,000. Information from these photographs was transferred to 1:6,000 base maps using a Bausch and Lomb zoom transfer scope. Draft vegetation maps were then field checked and refined, and a final vegetation map was produced for each of the Anacapa islets.

East Anacapa and Middle Anacapa have only three plant communities: Coastal Bluff, Coastal Sage Scrub, and Island Grassland. West Anacapa, the largest and most topographically diverse of the three Anacapa islets, has the above communities and examples of Island Chaparral, Island Woodland, and a vegetation that represents a broad ecotone between Coastal Bluff, Coastal Sage Scrub, and Island Grassland.

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PRIMARY PLANT COMMUNITIES IN VOYAGUERS NATIONAL PARK, MINNESOTA.

KURMIS, VILIS; MERRIAM, L.C.; WEBB, SARA

The vegetation of the Voyageurs Park has been affected by recurring fire and other natural disturbances. In the past, much of the park area has been logged, principally for pine, spruce and aspen. Since 1973 plant communities have been studied first, in the proposed development areas; and, later in the balance of the Park with the objectives of inventory, classification and implication of park preservation and management on existing communities.

The study was conducted in two phases: First, a reconnaissance of the Park during which 115 stands were visited and described; Second, intensive study of 46 stands judged to be representative of each community type. The method of synecological coordinates as developed by Bakuzis (1959; 1960) was used to evaluate the biotically effective part of the essential environmental regimes such as moisture, nutrients, heat and light. Moisture-nutrient coordinate axes were employed as a framework for plant community ordination and as an aid in classifying the investigated communities in ecological vegetation types.

The following communities were identified and studied: upland shrub-rock outcrop, jack pine, red pine, white pine, aspen, paper birch, spruce-fir, white-cedar, black ash, black spruce, muskeg, lowland shrub, and marsh. Of these, aspen is presently the major community type in the Park. Most of the aspen stands are over-mature and have a fire and/or logging origin. In the absence of fire, many stands will be replaced by shade tolerant conifers. However, in Voyaguers National Park, because of the frequent wind damage plus insect and disease incidence, aspen seems to be a more enduring constituent of the forest cover than previously thought.

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LICHENS OF VOYAGEURS NATIONAL PARK, MINNESOTA

Wetmore, Clifford

Lichens have been collected at numerous localities in the park to provide a lichen flora which might be of use in park planning, interpretive programs, and other research within the park. Observations were also made on the availability of lichens for winter caribou food, changes in the lichens present since 1901, lichens useful as indicators for air quality monitoring, and lakeshore lichens with respect to the fluctuating lake levels.

Collections were made at over 100 localities in the park to produce a complete survey of the lichen flora and find occurrences of rare lichens which might aid in long range planning and serve as a baseline for future research. Partial identification of the collections show that there are over 200 species in the park including some of phytogeographical interest and several that are very rare in northern Minnesota. A comparison with the few lichens collected by Bruce Fink in 1901 show some significant losses to the lichen flora in the past 78 years. This may reflect changes in the vegetation of the area because his collections were made during the early stages of logging and some species only grow in old forests.

Voyageurs National Park is a potential site for reintroduction of woodland caribou. Observations were made on the lichens available for winter food. Arboreal fruticose lichens are abundant in some areas and fruticose lichens on the ground are very abundant in most places. Compared with similar studies on the Slate Islands, Ontario, winter food for caribou probably would not be limiting if caribou are reintroduced into the park.

Xanthoria elegans, an orange rock lichen, is abundant along the shores of Lake Superior but not common around the large lakes in Voyageurs National Park. A reconnaissance survey was made in Kabetogama Lake and this lichen is present in some places but only where steep shore rocks face the open lake. Probably the occurrence of this lichen is mainly limited by the availability of suitable habitats rather than the fluctuating lake levels.

Collections have been made in all vegetational types and at each locality all species of lichens found were collected so that future studies can determine whether species are being eliminated. All of the label data from lichen collections in the park have been entered into the computer data base on lichens maintained at the University of Minnesota so that at any time accurate species lists or other kinds of retrievals can be obtained.

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THE FLORA OF ORGAN PIPE CACTUS NATIONAL MONUMENT

BOWERS, JANICE E.

A flora of the vascular plants of Organ Pipe Cactus National Monument was compiled over a 21-month period from 1977 to 1979. Five hundred nine species of vascular plants were found at the Monument. Nearly 75 percent of these plants have Southwestern, Sonoran or Latin American affinities.

There are several features of particular interest in the flora of the Monument. Several species which are common in desertscrub in Sonora, Mexico reach the northern limit of their distribution in or near Organ Pipe Cactus National Monument. The occurrence of these species in southwestern Arizona is probably due to mild winter temperatures and significant summer rainfall. Relictual chaparral and woodland species occur in the Ajo Mountains. Their presence there and evidence from fossil packrat middens (Van Devender, 1979) indicates a considerable change in vegetation and climate since the Pleistocene. The Ajo Mountains are relatively species-rich in comparison to other ranges in the Monument. This diversity could be accounted for by several factors, including a larger elevational range, a greater habitat diversity and more rainfall than is found in other parts of the Monument.

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BASE LINE TERRESTRIAL ECOLOGY OF FIVE APOSTLE ISLANDS

ROBERT THORSON BROWN

The five Apostle Islands studied were Oak, Bear, York Raspberry and Rocky. For each island, a soils map was prepared through intensive sampling. The forest vegetation was also intensively sampled and maps were drawn for each island showing forest type and some modifications of forest type by ground cover. Species lists for each island were developed. Fauna studied include amphibians, reptiles, birds and mammals. For the amphibians and reptiles, only species lists were made. For birds, comparative studies of breeding birds were carried out, and a species list including transients as well as breeding birds was prepared. For small mammals, a trapping census (with recaptures) was done. Squirrels, hares, deer, bears, and coyotes were censused by various means, and swimmers (beaver, otter, muskrat) were recorded on species lists. When appropriate, maps were constructed.

From these and other data, resource limitation maps were constructed. Such maps indicated the "fragility" of various portions of the islands if they were subjected to specific impacts (e.g. paths and trails, camping and picnicking, sewage disposal).

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A STUDY OF VEGETATIONAL CHANGES SINCE ESTABLISHMENT OF CAPE COD NATIONAL SEASHORE

Waggoner, Gary S.

A vegetation map of Cape Cod National Seashore has been produced based primarily on September 1977 black and white aerial photography at a scale of 1:12,000. Ground truthing was used to verify the accuracy of the map. Vegetation classes were mapped on appropriate 7.5 minute (1:24,000) U.S. Geological Survey Quadrangle sheets.

Twenty-one different classes are defined and mapped. The classification system utilized was that developed and used in a similar mapping effort conducted in the summer of 1962 by Randall (1962). This latter study was based on aerial photography taken in 1960, the year before Cape Cod National Seashore was authorized by Congress.

Maps from both studies were digitized and comparative analyses of vegetational differences were performed. Major vegetational trends in the area resulting from National Park Service administration are discussed. The importance of developing a well-defined classification scheme for similar studies is also stressed.

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VEGETATIONAL DIVERSITY OF THE SOUTHERN APPALACHIAN BALSAM MOUNTAINS

PITTILLO, J. DAN AND SMATHERS, GARRETT A.

The vegetation of the Balsam Mountains is one of the most diverse of the temperate deciduous forests. Soils are primarily Dystrocrepts and Hapludults at lower elevations and Haplumbrepts at higher elevations. These were derived by weathering of acidic gneisses and schists over long periods. The climate of the region is cool and moist, increasing in both factors with elevation.

Vegetational composition and structure were studied using 10 x 10 m releve plots located at 93 m elevational intervals. Eight communities were classified from these: floodplain, successional, xeric oak, mesic oak, cove hardwood, cove hemlock, birch boulder field and spruce-fir. Additional information was obtained from research papers for heath balds, grass balds, rock outcrops, and beech gaps. Floodplain woodlands occur in a limited area along the French Broad River at the base of the Balsams. Successional communities occur in old fields, cleared pasture lands, and burned over forests. The bulk of the area is covered with mesic oak forests with drier ridges inhabited by xeric oak forests. Moist draws and ravines are occupied by cove hardwoods, these changing into cove hemlocks and birch boulder fields at higher elevations. Beech gap forests occur in high elevation gaps between the wider distributed spruce-fir forests capping these mountains. Scattered inexplicably throughout the spruce-fir forests are grass balds. Also heath balds and rock outcrops occur in shallow soiled areas at high elevations. Comparisions of the vegetational diversity of these communities and those of the adjacent and better known Great Smoky Mountains will be discussed.

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SIERRAN SUBALPINE MEADOWS, KERN RIVER DRAINAGE, SEQUOIA NATIONAL PARK

BENEDICT, NATHAN B. AND JACK MAJOR

Sierran meadow ecosystems are an important natural resource for backcountry users. Few, if any, of the ecological relationships of Sierran meadows have been studied. The goals of this project are (1) vegetation description and classification of subalpine meadows, (2) correlation of vegetation types and species distribution with environmental factors, (3) the study of the origins and successional sequences of meadow ecosystems, and (4) the effects of meadow origins on meadow ecosystems. Broad meadow types are presented in relation to their geomorphic history and topographic position. Some of the possible causes of meadow formation and maintenance are discussed concentrating on subalpine meadows in the eastern portion of the Kern River Drainage. These include the relationships between meadow type and (1) ancient Sierran erosion surfaces, (2) glaciated basins, (3) recessional moraines, and (4) lateral moraines. Basic research on the ecology of meadow ecosystems will result in a more thorough understanding of Sierran meadows which, in turn, can be used to formulate appropriate management strategies suitable for the different meadow types.

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THE FLORA OF SOUTH FLORIDA: HOW SECURELY IS IT PRESERVED IN NATIONAL PARKS?

LOOPE, LLOYD L.

Over two-thirds of approximately 1500 native vascular plant species of Dade, Monroe, and Collier Counties, Florida, are relatively secure within the boundaries of Everglades National Park (land area of 284,000 ha; about 800 species of native vascular plants), Big Cypress National Preserve (149,000 ha; 580 species), and Biscayne National Monument (2000 ha; 300 species), despite threats from fire, exotic species invasion, hurricanes, and illegal collecting. Prospects for preservation are poor in areas other than those specifically devoted to conservation because of expanding urbanization, water manipulation, massive exotic plant invasion, and native plant removal.

Species richness of individual plant communities of South Florida decreases with lengthening hydroperiod and exposure to salinity. Highest species numbers are found in rockland pine forests and tropical hardwood "hammock" forests, which are rarely, if ever, flooded or subjected to saline tides. Such sites occupy less than 3% of Everglades National Park, but are inhabited by nearly 50% of Everglades plant species. Similar "upland" areas outside parks are undergoing the most intensive development. Many species with restricted ranges in such "uplands" outside parks are in great danger of extirpation.

An analysis of the status of rare plants in South Florida national parks has identified 170 taxa to be given consideration in park management, including all taxa appearing on State and Federal "endangered lists," local endemics, and other species regarded as rare. This information is necessary for fire management in parks, since rare plants of cypress strands and tropical hardwood hammocks are extremely vulnerable to fire. For most pineland and prairie species, maintenance of a near-natural fire regime through prescribed burning appears essential for preservation.

An assessment of the effectiveness of parks in floristic preservation in South Florida is illustrated by consideration of selected groups of species. Of 60 South Florida species recently classed by E. L. Little as "rare tropical trees," 45 are protected within national park areas. Parks provide protection for 32 of 63 taxa considered endemic to South Florida. Thirty of 39 species of epiphytic orchids and bromeliads currently native to South Florida occur in parks.

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PHYSICAL SCIENCES

RECOMMENDED POLLUTANT MONITORING SYSTEM FOR BIOSPHERE RESERVES

WIERSMA, G. BRUCE
BROWN, KENNETH W.

Biosphere Reserves have been established worldwide as part of the Man and the Biosphere Program of UNESCO. Part of this program, related to current international cooperative efforts in the area of pollutant monitoring on Biosphere Reserves and the bilateral agreement on the environment between the U.S. and U.S.S.R., includes the development of a pollutant monitoring system applicable to a large number of different Biosphere Reserves. The system must be able to produce data that are comparable between Reserves. In addition, it must be relatively inexpensive and able to be implemented by less developed countries. The Environmental Monitoring Systems Laboratory of the U.S. Environmental Protection Agency, in cooperation with the U.S. Park Service, has been working on the development of such a system for the last 2 years. Conclusions and recommendations for the design of a pollutant monitoring system result from analysis of pollutants which had a real or suspected long-term transport characteristic.

Types of samples collected on the Reserves studied to date include air, water, soil, vegetation, and forest floor. At least 10 sampling blocks were established. These blocks were subsampled and each subsample was analyzed 3 times.

Analytical procedures were chosen not only for their ability to detect suspected pollutants but also for their cost-effective nature. Multi-elemental analytical techniques were used whenever possible. Multi-organic analytical techniques were also used where available.

The data were analyzed using a model based on first order kinetics and exposure commitment analysis. Lead was used as a test pollutant. Calculated values agreed well with measured field values.

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AIR QUALITY MONITORING IN THE SOUTHWEST REGION NATIONAL PARK SERVICE

Yarborough, Keith A.

The Southwest Region of the National Park Service administers field areas which protect both natural and cultural resources and which have been set aside in the States of Arkansas, Louisiana, Oklahoma, Texas, New Mexico and northeastern Arizona. The August 1977 amendments to the Clean Air Act provided an important mandate to Federal Land Managers to protect air resources in their areas. This important legislation explicitly recognized air as a significant natural resource and made the protection of air resources and others called air quality related values an explicit management objective in certain mandatory Class I National Park Service areas from total suspended solids and sulfur dioxide air pollutants. The amendments also provided for studies to recommend other areas for possible redesignation to Class I.

To provide a data base of present air quality in selected Southwest Region areas, a program of air quality monitoring was undertaken in the late summer and fall of 1978. Results are:

1. Visibility measurements in cooperation with Environmental Protection Agency's Project VIEW show degradation of a regional nature in many areas.
2. Total suspended particulate sampling, with chemical analysis complements the visibility work but shows low concentrations which may be due to natural dust as well as power plants.
3. Fine suspended particulate sampling at five field areas in cooperation with EPA further shows dust to produce some visibility degradation as well as anthropogenic sources.
4. Air quality related value inventory at 12 selected field areas to support redesignation recommendations and to protect Class I Air Quality Related Values.
5. A special study at Chaco Canyon on present status of adverse impacts from air pollutants. This area is threatened by energy developments which surround it. Preliminary results show visibility degradation of a regional nature, partly from dust and partly from anthropogenic sources; but little adverse impacts on the ruins, vegetation or soils.

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ATMOSPHERIC DEPOSITION STUDIES IN THE GREAT SMOKY MOUNTAINS NATIONAL PARK

MATHEWS, JR., RAYMOND
LARSON, GARY
SILSBEE, DAVID

Anthropogenic emissions of acid-causing pollutants increasingly are found to influence the pH of precipitation on local, regional, national, and international levels. Low pH of precipitation in the United States was first identified in 1955-56 in the northeastern United States. Since that time, the region affected has expanded south and west. Recent data on the pH of precipitation in the Great Smoky Mountains National Park support that trend. In view of the potential impacts of the depressed pH of rainfall and snowfall on vegetation, aquatic organisms, and soil, a program was established to monitor the pH of precipitation and select streams in the Park. Early efforts were very restricted but the pH of precipitation was usually less than 5 and has been as low as 3.3 for snowfall. Measurements of stream pH showed depressions of up to 1 pH unit following heavy rains and snowmelt periods.

Present data now suggest that considerable variation in the pH of precipitation exists. Some of this variability is ascribed to the direction (trajectory) of air masses, local topography, prevailing winds, seasonality, and whether the precipitation is in the form of rain or snow.

An expanded atmospheric deposition program has been implemented in the Park and includes weekly samples from four locations near the Park boundary and one from the highest elevation (about 6,000 ft. MSL) in the Park. An automatic atmospheric deposition collector for wet/dry fall is utilized at each location to provide long term analysis and trends. The National Weather Service's Climatic Center will provide correlating data for wind trajectory and speed, rain relief patterns, and temperature profiles for surface to 20,000 feet using ground reconnaissance stations stations in the Park and high elevation weather balloons. The relationships between amount of precipitation, pH of precipitation, and the extent of the pH depression in select streams in the park are presently being monitored in closely spaced data sets using satellite remote sensing instrumentation.

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POLLUTANT MONITORING IN THE OLYMPIC NATIONAL PARK BIOSPHERE RESERVE

BROWN, KENNETH W.
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Scientific interest in global contamination has been instrumental in the establishment of 33 Biosphere Reserve sites throughout the United States. These sites, including many pristine areas that are and have been protected from industrial development, serve as areas in which present and future environmental pollution can be assessed.

The Olympic National Park Biosphere Reserve was selected by the U.S. National Park Service as the second site, following Great Smoky Mountains National Park, for pollutant monitoring studies. These studies, conducted by the U.S. Environmental Protection Agency, were designed to identify levels of trace elements and organic contaminants in both the physical and biological media. Based on the Great Smoky Mountains experience, nine remote sites within the Park were selected for intensive sampling. Sampling areas were located in the Hoa, Quinault, and Dosewallips River drainages; at Anderson and Grand Pass; and near the northern most edge of Blue Glacier. Their proximity to vehicle-traveled roads varied from 5 to 12 miles. An additional sampling area was located close to La Push near the Pacific Ocean.

The media sampled included air, water, soils, litter and several different plant species. These samples were processed and analyzed for selected organic, as well as 26 different heavy metal contaminants such as lead, cadmium, nickel, and zinc. Additional analyses included airborne particulate characterization, such as size determinations and the identification of chemical constituents.

The data obtained identify present baseline contaminant concentrations and will assist in resource management and environmental quality programs.

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A STUDY OF AMBIENT AIR QUALITY AND VISIBILITY IN NATIONAL PARKS

Stephens, N. Thomas,* Larson, Gary,** and Albee, T. F.*

Ambient air quality, visibility, and other related parameters have been the subject of study in the Great Smoky Mountain and Shenandoah National Parks. Data relating concentrations of ozone and sulfur dioxide in vertical and horizontal distribution in rugged and remote terrain within and near the park boundaries have been collected in an intensive study over the past several months utilizing a specially equipped twin engine aircraft. Additional data collected by the aircraft includes light scattering (visibility), dew point temperature, and aerosol composition.

Data to date indicate a substantial difference in ozone concentrations on the south side of the park which is not as subject to anthropogenic influences as the north side. Ozone concentration differences on the order of 20 to 30 ppb are common. High ozone concentrations of 90 to 100 ppb have been recorded, with high values observed at elevations corresponding to the height of Clingman's Dome. Sulfur dioxide concentrations ranging from 20 ppb in October to less than 2 ppb in May have been observed. These concentrations have shown a tendency to be uniformly distributed in the horizontal. Visibility ranges have been measured varying from 10 to 180 miles with a definite relationship to the visible haze layer. Composition of the sampled aerosols shows a strong presence of sulfates. Early morning and afternoon measurements show the influence of meteorlogical parameters on concentrations of pollutants at lower levels, however, elevated samples (which are still "ground level" to mountainside vegetation) show relatively constant values with the potential for greater damage impacts.

Ground level concentrations, along with meteorological data collected can be used for analysis of cause and effect of important concerns such as visibility degradation, acid precipitation impacts, and vegetation damage. Data and analyses are being correlated with research being concurrently conducted on vegetation impacts in the parks.

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IMPACT OF PHOTOCHEMICAL OXIDANT TO WHITE PINE IN THE SHENANDOAH, BLUE RIDGE PARKWAY AND GREAT SMOKY MOUNTAINS NATIONAL PARKS.

SKELLY, JOHN M.; DUCHELLE, STEVE; KRESS, LANCE W.

Photochemical oxidant (Ozone) impact to pine (Pinus strobus) has been evaluated since 1977 in the Shenandoah (SNP) and Blue Ridge Parkway (BRPW) National Parks. A more recent survey (June, 1979) was conducted in the Great Smoky Mountains National Park (GSMNP). Oxidant concentrations were first (1975-1976) recorded with Mast Oxidant Meters; from 1977 Bendix chemilluminescent ozone analyzers have been in use at the 5 monitoring sites throughout the study area. Specific oxidant episodes were recorded in June-July 75, June 76 and July 77. Although no major episode occurred in 1978, consistently higher levels were recorded than during the previous 3 years. Very low oxidant concentrations have persisted through June of 79. Initial surveys were conducted in 75 and since 77, a total of 315 trees within 32 plots located along the BRPW and SNP road system have been evaluated several times each year. An additional 41 trees located in 4 plots were examined during June 79 in the GSMNP. A scoring system comprised of needle retention (0-3); length (0-2); and condition (0-4) was used on upper and lower crown foliage for a total possible tree score of 18. Sensitivity groupings of 16-18, 12-15, and 0-11 indicated trees that were tolerant, intermediate or sensitive to ozone. Analysis of oxidant data and white pine injury in the SNP and BRPW following episodes revealed increases in the percent of trees in the sensitive and intermediate classes. During 1977, the percent of total trees in the tolerant class dropped from 37% in June to 1% in December whereas the corresponding percentages in intermediate and sensitive classes increased from 50 to 77% and 4 to 21%. The most severe ozone episode occurred July 14-24, 1977 with 36% of the readings over 8 pphm for the month (High=16.8 pphm 1 h aver.). Only one evaluation was conducted in 78 and 27, 65, and 8% of the trees were tolerant, intermediate and sensitive respectively; a June 79 survey reflected little change. Fourteen of the 315 trees initially tagged in 77 have died. Ten of these have declined each year with typical oxidant symptoms. The remaining 4 were removed following non-pollution related damage. The June 79 survey in the GSMNP indicated that 17, 80, and 3% were tolerant, intermediate, and sensitive respectively. Acute oxidant symptoms were found on the newly expanded needles of two trees. Continuing studies will include other tree species with attention to growth reduction and biomass losses. High oxidant impact areas as identified by airborne monitoring platforms will also be surveyed.

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OZONE AND CONIFER INJURY IN SEQUOIA AND KINGS CANYON NATIONAL PARKS

VOGLER, DETLEV R.

Elevated levels of ambient ozone were first reported in Sequoia and Kings Canyon National Parks in 1974. Subsequent investigations have revealed excesses of Federal and State ozone standards during the summer months at Park Ridge Lookout (2300 meters elevation) and at Lodgepole (2040 meters). Monitoring at nearby sites in the southern Sierra Nevada and at foothill and San Joaquin Valley locations reveals a daily pattern of pollutant transport into the mountains from urban areas to the West.

Ozone has been implicated in the decline and death of conifers in the San Bernardino Mountains east of Los Angeles. Injury symptoms on ponderosa and Jeffrey pines -- identical to symptoms associated with ozone in southern California -- have been discovered near the monitoring sites in the National Parks, suggesting that a potential exists for severe ozone damage to these highly-scenic forests.

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A STUDY OF IMPACT OF MAN-MADE NOISE ON NATURAL SOUNDS

SCHECHTER, HOWARD R.

A study of the impact of man-made noise on natural sounds has been completed for the U.S. Department of the Interior, National Park Service, Indiana Dunes National Lakeshore, by IIT Research Institute. This area includes territory bordered on the west by Gary, Indiana, on the east by Michigan City, Indiana, the north by Lake Michigan, and on the south by a system of interstate highways running east-west, connecting the Chicago metropolitan area with the northeastern portion of the continental U.S. and Canada. The acoustic analysis of noise impact on natural sounds has entailed over a year and a half of studies utilizing the latest in multi-measurement technique approaches. These methodologies have helped characterize what constitutes a natural sound in an environment in which man-made noise may sometimes predominate.

Measurements have been performed in all four seasons of the year, defining the range of natural bird, insect, and other wildlife sounds through cognizant mating, hibernation, and dormant cycles. As a result, the study has shown how the relative impact of man-made noise propagation changes over a full year period. A map presenting the results of measurements and displaying such changes in noise impact, using a color overlay technique, has been generated for summer/fall and winter/spring seasonal conditions. The following key conclusions have resulted:

- Quiet areas do exist in the Park on an entire four season basis, but only in those locales distant or sheltered from interstate highways. Quiet areas are defined as those locations free of man-made noise for 90 percent of the time.
- Man-made noise predominates at boundary areas to major interstate and arterial highway systems. In these areas natural sounds are impacted 90 percent of the time.
- Insect sounds in the summer/fall season predominate the acoustic environment for nearly all of the early evening and nighttime temporal periods, producing a natural masking effect to man-made noise in a large portion of the Park.
- Natural shielding of man-made noise sources is provided by large dunes and other types of terrain indigenous to the Indiana Dunes National Lakeshore.

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AIR QUALITY RELATED VALUES STUDY AT CHACO CANYON NATIONAL MONUMENT

HERRIMAN, WALTER, GARLAND MOORE, BRIAN McHUGH and KEITH A. YARBOROUGH

Chaco Canyon is an internationally significant area in which the National Park Service is preserving the ruins of the preColumbian Chacoan culture which peaked around 1100 A.D. These ruins have been determined to be the architectural equivalent of the Acropolis in ancient Athens, Greece--and in particular, its Parthenon. Recently, archeologists have discovered evidence which indicates that the Chaco Canyon area was a major trade center linked by an extensive road system to other outlier areas throughout the San Juan Basin, and perhaps far beyond. Artifacts from meso-America have been found at Chaco Canyon.

The amendments to the Clean Air Act of August 1977 explicitly recognized air as a significant natural resource along with other air quality related values which are important attributes to certain National Park Service administered areas. These were designated to be of mandatory Class I air quality status. Chaco Canyon is being studied for recommendation of redesignation to Class I. This is necessary because Chaco Canyon is surrounded by extensive energy development in the San Juan Basin of northwestern New Mexico which includes: large existing and proposed coal-fired power plants, extensive uranium mining and milling, oil and natural gas, coal gasification, hydroelectric power by pumped storage, and large-scale coal strip mining. All of this development combines to make Chaco Canyon the most threatened cultural resource area in the National Park System.

To provide protection for the significant cultural and natural resources of Chaco Canyon which are air quality related values, a detailed study has been undertaken. This includes monitoring:

- --of visibility, and of total and fine suspended particulates with chemical analysis; for air quality baseline determination. Results show regional degradation due partly to dust and partly to anthropogenic sources.
- --of seismic activity to observe natural effects viz-a-viz energy development related blasting. Results show possible adverse effects on the ruins.
- --of surface water flows and quality in the arroyos to assess uranium mine dewatering effects in the area. At present baseline data are being taken to define natural occurrences. The U-mine dewatering is just starting.

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VISIBILITY IN THE SOUTHWEST

MALM, WILLIAM, WALTHER, ERIC, KLIENE, MARVIN, AND O'DELL, KENNETH

Recognizing the importance of visibility to the experience of a visitor to pristine areas in the United States, the Environmental Monitoring Systems Laboratory, U.S. Environmental Protection Agency, entered into an agreement with the National Park Service to deploy an experimental research telephotometer network at 14 national parks in the Southwest. Objectives of the network are: 1) evaluate the effectiveness of several physical variables in their ability to characterize visibility, 2) evaluate the ability of multiwavelength telephotometers to measure these variables, and 3) determine the temporal and spatial dynamics of visibility degradation on a regional scale.

Visibility is more than the ability to see an object at the distance at which it just disappears. Visibility includes the effects that the atmospheric constituents have on the ability of an observer to see color, texture, and form of both near and distant vistas. Vista contrast and color, and their temporal change, most effectively represent variations in atmospheric visibility. In addition, these two variables can be used to establish relationships between human perception and instrumental measurements. Because contrast and color are vista specific, visual range remains a useful interpretive parameter when an intercomparison of data obtained from different vistas or from different parks is desired.

Average vista contrast for each of the parks monitored is compared to "standard" documented color slides. Through this comparison, it is possible to pictorially describe visibility change in each of the parks. Analysis of data for the months of August 1978 through May 1979 shows that the fall season has the best visibility. Grand Canyon and Navajo Monument have the best visibility, while Big Bend and White Sands have the worst. Visibility at Chaco Canyon, Mesa Verde, and Bandelier, while better than at Big Bend and White Sands, is still rather poor.

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LONG DISTANCE TRANSPORT OF AIR POLLUTION INTO SEQUOIA, KINGS CANYON, YOSEMITE AND LASSEN NATIONAL PARKS

WILLIAMS, WAYNE T.

Long distance transport mechanisms for air pollutants impacting the California National Parks are described.

I. Air pollution from the Central Valley and San Francisco Bay Area concentrates along the western slopes of the Sierra Nevada at inversion boundary layers and river drainages. The phenomenon is especially apparent in the southern part of the mountain range. The yellow pine and mixed conifer forests are impacted to altitudes up to 3100 meters and as far as 120 kilometers from the nearest urban sources of pollution. The dominant tree species are hypersensitive to ozone, and exhibit symptoms of oxidant stress along the exposed ridges deep into the Parks. As examples, the pollutants follow the V-shaped river canyons of the Kings River to elicit symptoms as far as Boyden Cave, and the East and Marble forks of the Kaweah River as far as the Mineral King Valley and beyond Cresent Meadow. Pollutants appear to impact the Parklands as wave fronts in a diurnal fashion during the smog season from May through November in concentrations and durations more than sufficient to cause symptoms through seasonal and plurannual accumulative doses. Several dominant conifers including ponderosa and Jeffrey pine, and California black oak (Quercus keloggii) commonly are stressed by oxidants and show visible symptoms of disease.

II. A point source model for long distance transport of pollutants was constructed for the Central Valley of California in the north from Chico/Oroville to Lassen National Park. This was in response to a proposal to construct a 1600 Megawatt coal fired power plant directly downwind from the Park. The power plant would emit 45.4 tons of sulfur dioxide, 114 tons of nitrogen oxides, unreported tonnages of fluorides, and an array of toxic heavy metals daily for 35 years. Lassen Park boundaries lie some 95 kilometers from the proposed site, and the topography of the montane slope plus favorable meteorological conditions would favor channeling of an intact plume into the Park. It has been demonstrated (Atmos. Environ. 12:2101) that point source plumes in the Central Valley can maintain their integrity for such distances, and that NO_x portions of power plumes convert to ozone via photochemical processes in excess of concentrations necessary to cause ecological degradation. These conversions occur near plume termini of even greater distances than 95 kilometers (Science 202:1186). Ozone, sulfur dioxide, nitrogen oxides and fluorides react synergistically against vegetation with deleterious results greater than if individual gases acted separately. The implications against forest ecosystems in the Parks are reported.

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ELECTRICAL PROPERTIES OF AIR IN THE CARLSBAD CAVERNS

WILKENING, MARVIN

Air in unventilated caves is known to have radon and daughter product concentrations that are relatively high with respect to outdoor air. The effects of this radiation upon the electrical conductivity, space charge, and electric fields are addressed in this study. Physiological effects on living organisms, if any, are not treated.

The measurements of radon concentrations made by our group beginning in 1973 and by others show that the air in the Carlsbad Caverns during the summer months is approximately 200 to 300 times the concentration in outdoor air. One of the results of the presence of the radon is the greatly enhanced production rate of ions in the cave air. Studies conducted in the Carlsbad Caverns in the period 1977-78 gave the results which follow. The ion concentrations of both negative and positive signs in the cave exceed those of the outdoor air by a factor of about 100 in the fall to up to 800 in the summer months when radon concentrations are the highest. Negative ions are generally slightly more abundant than the positive ions resulting in a small net negative space charge. This excess of negative ions produces a small but measureable electric field of about 1 volt per meter having a direction such as to cause negative ions to drift toward the walls of the cave. For comparison the outdoor fair weather electric field is approximately 100 volts per meter pointing toward the ground. The normal space charge is positive at about 100 ions per cm^3. The electrical conductivity of air in the Caverns averages about 150×10^{-14} $(ohm\text{-}meter)^{-1}$ which is about 100 times the conductivity of outdoor air during the summer radon maximum. The average mobilities of the ions, both positive and negative, were found to be appreciably less than for those in the free atmosphere.

The differences in the electrical properties of air in the Carlsbad Caverns and those of the free atmosphere can be attributed to the high rate of ionization from the relatively high radon concentration and to the high humidity in the cave.

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THE DIURNAL WIND REGIME IN THE CENTRAL HIGH SIERRA

MORGAN, D. L. and W. F. SLUSSER

During the summer and fall continuous wind and temperature data were gathered from mechanical weather stations placed in a remote area above timberline in Sequoia National Park. Interest in obtaining data of this nature stems from the paucity of quantitative information on the daily temperature and wind regimes of high mountain areas. Documentation of mountain winds is essential to the understanding of air pollution transport and of the wind energy potential of these unique areas.

Analysis of these data show verification of some important ideas. The influence of the synoptic wind on the diurnal, local wind systems is quite complex but definite relationships seem evident and expected seasonal changes in the timing and intensity of the local winds is apparent.

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SYSTEMATIC CHANGES IN BEACH PROFILE AND NEARSHORE TOPOGRAPHY

Weishar, Lee and Wood, William

A three year set of monthly beach and nearshore topographic profiles have been obtained from the southeastern shore of Lake Michigan in the Indiana Dunes National Lakeshore (I.D.N.L.S.). This ongoing study was initiated to determine the temporal and spatial beach and nearshore characteristics of a typical sandy Great Lakes coastline.

Empirical eigenfunction analysis was performed on the three year (1976-1978) data set of beach and nearshore topographic profiles measured monthly from May to November along the coast of I.D.N.L.S. This empirical eigenfunction analysis results in a series of eigenvalues and their corresponding temporal and spatial functions which describe the variance in the data. This analysis determined that the major variations contained within the monthly data set could be explained by the first three eigenvalues and their corresponding temporal and spatial functions.

The first three eigenvalues represent approximately 97% of the total variance contained within the data. The majority of the variance contained within the data is represented by the first eigenvalue which represents the mean beach profile. The second most important eigenvalue is spatially reflected in the migration of the nearshore bars. The temporal signature of this eigenfunction corresponds to the passage of meteorologic systems. The third eigenvalue is spatially represented by small deviations from the mean along the entire profile line. This eigenvalue's temporal variation is reflected in the seasonal variation of lake level.

The results of this analysis have been used to conceptualize a predictive model for beach and nearshore profile changes. The predictive model will combine spatial and temporal components to forecast changes in the beach and nearshore topographic profile. The spatial component will be represented by a mean beach profile, while the temporal components would be represented by wave climatology and lake level data.

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STORM IMPACT ON SYSTEMATIC CHANGES IN BEACH AND NEARSHORE TOPOGRAPHY

Wood, William; Weishar, Lee and Davis, Stephen

Changes in beach and nearshore topography have been monitored, for the past five years, along a section of coastline at the Indiana Dunes National Lakeshore. Empirical eigenfunction analysis of beach and nearshore data have shown that topographic changes are systematically related to seasonal wind wave and lake level variations (see companion paper by Weishar and Wood).

Anomalous variations in these periodic, systematic beach and nearshore topographic changes indicated that the eigenfunction analysis was sensitive to episodic events. A detailed analysis of topographic changes, at close time intervals, has shown that storm events are readily detected as significant variations in the temporal eigenfunctions. Furthermore, storm intensity appears to be reflected in the relative value of the temporal eigenfunction, weighted by its corresponding eigenvalue.

Most significant in these results is the suggestion that storm impact on a coast can be predicted, in a statistical context, from climatological data. Specifically, these climatological data can be used to develop a probability distribution of episodic storm events and their intensity. Since this distribution is the episodic portion of the "forcing" on the second eigenfunction (wind waves and currents), it can be used to predict changes in beach and nearshore topography. Herein lies the potential to develop models capable of predicting both periodic and episodic changes in topography for sandy coastlines of the Great Lakes.

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A COMPARISON BETWEEN A PLEISTOCENE AND A HOLOCENE BARRIER ISLAND: HARKERS ISLAND AND SHACKLEFORD BANKS, CAPE LOOKOUT NATIONAL SEASHORE

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The National Park Service, based on Harkers Island, is about to take control over Shackleford Banks. Both islands are underlain by the same late Pleistocene and older Coastal Plain sediments. During the most recent Pleistocene sea level rise Harkers Island migrated, from a position further offshore than Shackleford Banks, landward to its present position. In doing so it overrode its own tide dominated muddy lagoonal sediments. Overwash accretion on the backbarrier side of Harkers Island was the mechanism responsible for its migration. Harkers Island attained its present position some time between 23,000-30,000 years ago when sea level was at least as high as the present.

The very coarse shelly sediment beneath Shackleford Banks and beneath the adjacent backbarrier lagoon suggests that this barrier is underlain by inlet fill deposits. The combined observation of relict flood tidal deltas, relict recurved ridges, and the use of historical maps and C^{14} dates establishes a sequence dating repetitive inlet opening and migration. Shackleford Banks is entirely underlain by inlet fill sediments, the oldest of which are probably younger than 4800 years.

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SEDIMENTOLOGY OF TWO SMALL WASHOVER DEPOSITS AT PADRE ISLAND NATIONAL SEASHORE, TEXAS AND ASSATEAGUE ISLAND NATIONAL SEASHORE, MARYLAND

GARROW, HOLLY CRANDALL

Two small washover deposits at Assateague Island National Seashore and at Padre Island National Seashore were sampled within a few days of deposition. At each site, approximately 250 ft. of trenches were cut and 74 sand samples from 3 to 5 depths were collected for analysis from a grid-like array. Each sample was sieved at 1/4 phi intervals, was graphically analyzed and its moment statistics were calculated. The samples from Padre Island are fine and uniform in grain size, very much like the adjacent beach and dunes. Within the washover distinct bedform structures form the, ocean to landward, sequence of antidunes, planebeds, ripples and again planebeds. These latter planebeds consist of laminations that can be followed more than 100 ft. until they become indistinct at the intersection with the watertable. The Assateague Island sands, by contrast, are much coarser and less well sorted and possess the less distinct sequence of bedforms, from ocean landward, of lens-shaped beds, interpreted as dunes, ripples, planebeds and crossbedded dunes. Whereas many of the Assateague Island samples are polymodal none of them appear to be made up of 2 distinct populations that would allow interpretation of transport mechanisms as suggested by Vischer (1969). None of the Padre Island samples show bimodal distribution. Correlation of moment measures with each other and with spacial coordinates yield three significant correlations common to the two data sets: mean with standard deviation (sorting), standard deviation with skewness, and skewness with kurtosis. At Assateague Island samples collected further back from the beach were more negatively skewed than those nearer the beach. When the moment statistics for all samples from both islands are compared to Friedman's (1960) three statistical relationships used to distinguish beach, dune and river environments from one another, two plots result in discordant relationships while the third is concordant with his environmental boundaries.

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SANTA ROSA ISLAND, NW FLORIDA AND THE MISSISSIPPI-ALABAMA BARRIER ISLANDS - GENETIC COMPARISONS

OTVOS, ERVIN G., JR.

Closely-spaced core samples from island, lagoonal and mainland areas are the essential tools in the nearly completed study of the Miss.-Ala. barrier islands and the ongoing investigation of Santa Rosa Island. Major island areas belong to the Gulf Islands National Seashore, U.S. Park Service. All Mississippi barrier islands emerged during the late Holocene from subtidal bars and created an extensive lagoon (Mississippi Sound) landward of them. Dauphin Island, Ala. began around a high Pleistocene ground and preliminary indications suggest a very similar genesis for Santa Rosa Island.

The six Miss.-Ala. barrier islands stretch for an approximate distance of 140 km, reach elevations of 4.5-14.1 m and widths of 1-2 km. Subsurface exploration revealed that eastern Dauphin Island is underlain at very shallow depth by oxidized and humate-impregnated Pleistocene deposits that extended above sea level during the Middle-Late Holocene transgression. This core area provided the base for the subsequent spit growth that created the western island segment. The islands overlie open marine-nearshore muddy and occasionally not well sorted sands, deposited well below low-tidal levels. Five lines of coreholes across the Sound prove the open marine character of the earlier Holocene sediments.

Santa Rosa is an 84 km long, 0.3-1.0 km wide island, covered by 2-12 m high dunes. Unlike the Mississippi Sound, no streams empty into the narrow Santa Rosa Sound. In sharp contrast with most of the Miss.-Ala. barrier islands, only very minor westward progradation occurred since 1856. Drilling results thus far have shown that certain eastern and central Santa Rosa Island areas at shallow depths are underlain by Pleistocene sands. The Biloxi Formation, a late Pleistocene open marine nearshore and brackish inshore unit of the northern Gulf provides a well correlatable horizon under the mainland shores and the Island. Holocene sound deposits are thin north of them and of highly brackish character (Ammotium salsum - fauna). The western island segment formed by westward progradation; both the western island and brackish recent bottom sediments of adjoining Santa Rosa Sound areas are underlain by Holocene nearshore open marine deposits with Rosalina columbiensis, Hanzawaia strattoni, Elphidium incertum mexicanum. There exists no proof for a landward migrating barrier island system during the latter part of the Holocene transgression, as assumed for the Atlantic and the Texas coasts.

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HUMAN RELATED SHORELINE CHANGES IN PETIT BOIS ISLAND WILDERNESS, GULF ISLANDS NATIONAL SEASHORE

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Maintenance dredging of the littoral drift impoundment basin on the western margin of Petit Bois Island removed 4 acres of the prograding beach of this actively migrating barrier island in the autumn of 1978. An additional 2.7 percent of the study area eroded by January 1979. A low pressure system, originating over central Mexico, produced storm conditions with winds from 230° T in the Petit Bois vicinity on 24 and 25 February 1979. This storm eroded 53.1 percent of the study area, including primary dunes on the west tip (orientated 300° T). During the same period, the western tip (orientated 285° T) of Dauphin Island, the control study area, eroded by 1.2 percent and 1 percent, respectively. Based on isobaric patterns from synoptic surface weather charts, the geostrophic wind speed was estimated at 22-27 knots. Wave hindcasting by the methods of Sverdrup, Munk, and Bretschneider provided estimates of the significant deep water wave height (9.1 feet) and period (6.9 seconds) for the episode. Wave refraction coefficients of 1.74 and 1.18 for the western tips of Petit Bois and Dauphin Islands, respectively, were estimated by the orthogonal method. From this information, refracted wave heights, wave breaking distance from shore, and wave energy expended per lineal foot of beach for the western tips of Petit Bois and Dauphin Islands were found to be 15.2 feet, 800 yards, 4.133×10^7 foot-pounds per hour, and 10.4 feet, 1970 yards, and 1.935×10^7 foot-pounds per hour, respectively. The shoreline changes observed on the western tip of Petit Bois Island relative to those on Dauphin Island are shown to be related to the presence and orientation of the deep water channel (orientated 221° T) which converges southwesterly waves on to the western tip of Petit Bois, and to the dredging of the impoundment basin which effectively removes the beach buffer, thereby allowing direct wave attack on the dunes of Petit Bois Island.

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EFFECT OF LARGE ORGANIC DEBRIS ON CHANNEL MORPHOLOGY AND PROCESS IN THE STREAMS OF REDWOOD NATIONAL PARK

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Large organic debris is a major control on channel morphology and process in small to intermediate sized streams draining coastal redwood forests. Specifically, debris influences local width, depth and gradient, as well as sediment storage and transport capabilities of a stream. Due to the extreme size of material derived from redwood forests and its long residence time in the channel (locally exceeding 200 years), debris is responsible for much of the variety of aquatic habitat found in the streams studied in Redwood National Park.

The amount of debris loading in a reach, measured in Kg/m^2 of active channel, is dependent on a number of factors, including delivery rate of trees to the channel by mass wasting, bank erosion and windfall, discharge, drainage basin area, geology and stream gradient. An inverse relationship between stream size and loading, with minor exceptions, holds for this area. Delivery rate of debris tends to be higher in headwater streams due to more mass wasting; furthermore, debris is not transported out of the system prior to decay. The chance that in-channel debris will move increases downstream: in intermediate sized streams, large debris may be transported during extreme events while in large streams, such as Redwood Creek, debris may be transported during moderate events.

A stepped-bed profile is often produced in small streams by debris jams, wherein much of the potential energy loss in a reach occurs at small debris-related falls and cascades while pools form adjacent to the jams. In low gradient streams, differential scour around debris produces similar features. Debris jams, particularly those formed in redwood forests, may markedly increase the sediment storage capacity of streams over the non-debris loaded condition. The additional storage compartments, acting as a buffering system, may enable the stream to tolerate significant aggradation or degradation without a concomitant change in channel pattern. Testing of this hypothesis is the subject of continued research. The management implications of this work are important: disturbance of watersheds in and adjacent to newly acquired park land by timber harvesting has caused, and will continue to cause, sedimentation problems. Future rehabilitation work will be designed to improve and preserve the anadromous fishery resource. Although there may locally be excess logging debris in the channels which would act as a barrier to upstream migration of the salmon and steelhead runs, our results suggest that a good deal of the debris should be left in the stream to provide diverse spawning and rearing habitats.

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THE DEVELOPMENT OF NATURAL ROCK ARCHES AT ARCHES NATIONAL PARK, UTAH

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It has long been thought that the natural sandstone arches of the American Southwest were the results of freak erosion. Recent evidence appears to show, however, that the rock arch is mechanically self-perpetuating. In all rock arches there is an on-going redistribution of the in-situ static stress field. Arches appear to be relatively monolithic blocks of rock with stiffness and/or permeability differences. All that is required to initiate the arching process is an initial perturbation of the monolith; such as seep-undercut alcoves or the undercutting scour of a twisting stream channel. The arches we see today do not represent the ancient limits of hydraulic erosion.

Natural rock arches within the Entrada sandstone and the San Rafael Group have been studied. A suite of distinctive features common to all were observed. These included: strong development of uniaxial joint sets; unique constraining geometry; stiffness and lithologic boundaries that control the limits of the arches; and the predominance of stress relief joints or poorly developed conjugate joints in the beds where arch formation occurs. A geological model was formulated using three units that border or contain all arches within the Park. Testing of these units showed not only predictable strength anomalies, but differences in load-displacement stiffness and permeability as well. The beds which contain arches were found to be less stiff than overlying beds. Assuming that elastic strain release occurred during unloading of the overburden, the less stiff beds should display a greater amount of stress relief jointing, or volumetric expansion -- either of which leads to a higher susceptibility to erosion. These traits are displayed in the field. Localized stress relief joints can act to convey water and promote seep cutting at contacts with lower, less permeable beds. Volumetric strain could cause a bulging out of the bed. Either process acts to make for a series of blocks with limited constraint that are held only by the tensional strength of the rock. Arching as a result of tensional pull-out of the blocks would then proceed along lines of equal stress (compression trajectories).

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DEVELOPMENT OF COLLAPSED GLACIAL TOPOGRAPHY IN ADAMS INLET, ALASKA

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Changes in ice-contact deposits on the south side of Adams Inlet in southeastern Alaska have been monitored by ground-level studies (10-year record) and aerial photographs (40-year record). The deposits consist mainly of a kame terrace and a fan delta, both of which are still ice cored and undergoing collapse. The kame terrace, formed along the margin of Adams Inlet Glacier by lateral and englacial streams, is now dominated by hummocky topography with small stream channels. The channels, which run directly downslope, head and sometimes end in hummocks. These channels are developed by the emergence from glacier caves of subice meltwater and basin runoff, sometimes in the form of stagnant-glacier bursts. Some lineaments in the terrace form by cave collapse. Backwasting rates for the gravel-covered sides of these deposits are 2 to 5 m a^{-1}, while surface lowering beneath thicker gravels is probably less partly because of the covering by poplar, spruce, willow and Dryas.

The fan delta formed at a later stage as inflowing streams covered the glacier remnant near sea level with sediment from easily eroded outwash and till deposits. Continued collapse of this feature has altered the configuration of the shore and killed young willow trees, now 5 m below high tide. Some of the early stages in the development of these ice-contact deposits are observable at nearby wasting ice masses, such as Burroughs Glacier Remnant, and suggest that inflowing streams and glacier caves are important factors in the formation of these deposits. Other factors to be considered include ice movement, drainage-basin size, slopes, sediment supply, and lake or sea level.

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HOLOCENE GLACIER FLUCTUATIONS IN WATERTON-GLACIER INTERNATIONAL PEACE PARK

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Layers of volcanic ash in sediments, once identified as to source, provide dated stratigraphic markers that can be used to bracket ages of glacial deposits. This technique is being used in Waterton-Glacier in an attempt to date minor glacial fluctuations that have occurred since the last major glaciation (roughly the last 10,000 years). Results so far suggest one Early Holocene advance and one very recent advance, both very minor in extent.

Air photographs show that in the majority of cirques and upper valley bottoms only one end moraine is present (or recognizable). These moraines are generally small, unvegetated, bear no volcanic ash, and are situated very small distances from headwalls or just beyond present-day glaciers or firn banks. The sparse, small lichens on these moraines suggest they are only a few hundred years old.

In several cirques (over 60 in Glacier, about 10 in Waterton) an older moraine is found. These moraines are usually situated a few hundred meters beyond the younger moraines, and bear shrub and forest vegetation. Several of these sites have been visited in the field. The older moraines commonly bear a reddish-colored, fine-grained ash; electron microprobe analyses of magnetites from Waterton samples of this ash show MgO and TiO_2 percentages of about 2-2.3 and 8.3-8.9 respectively, indicating Mazama ash from Crater Lake, Oregon. Mazama ash is about 6600 years old. Samples of this ash from Glacier are now being analyzed.

At some sites a second ash, coarser-grained and gray or tan in color, underlies the red ash. Preliminary magnetite analyses suggest that this older ash is a mixture of Mazama and some other as-yet-unidentified ash(es), perhaps from the Mt. St. Helens group in Washington. In any event, barring further complications, the Early Holocene glacial advance occurred before 6600 B.P. The minimum date presumably will increase if and when the make-up of the older ash is unraveled. The results show that ice cover in these parks was not much greater than at present over most of the Holocene.

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EVIDENCE FOR PRECAMBRIAN GLACIATION IN THE DEATH VALLEY REGION

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The Precambrian Kingston Peak Formation (between 1200 and 850 million years old), exposed in the Death Valley region, was possibly deposited during an ancient glaciation and at a time of continental rifting. Study of the formation in certain areas has revealed models for its depositional environment and research is underway to elucidate its structural history and depositional environment in the southern Panamint Range.

The Kingston Peak Formation crops out in a north-south belt, including the Funeral Mountains and Panamint Range, and an east-west belt, south-east of Death Valley. It characteristically includes diamictite (conglomeratic mudstone) as well as sandstone, siltstone, conglomerate, limestone and some basalt, and is in places metamorphosed to greenschist and amphibolite facies. In the east-west belt of exposure, a northern and a southern facies have been distinguished. Troxel (unpublished) subdivides the northern facies into three members: 100-500 m of argillite and quartzose sandstone overlain by 150-400 m of diamictite and 1000-2000 m of siltstone and sandstone with beds of conglomerate and diamictite. In the southern facies, Basse (1978) recognises two units: a lower one consisting of about 500 m of mainly sandstone and argillite and an upper one, about 800 m thick, of diamictite, conglomerate and conglomeratic sandstone. In the southern Panamint Range the formation consists of three members. The Surprise member contains 120-490 m of diamictite with subordinate sandstone and basalt. Capping it is a well-laminated, 2-50 m thick, grey limestone, the Sour Dough limestone member. The overlying South Park member consists of 80-300 m of interbedded sandstone and limestone below sandstone, siltstone and conglomerate. Further north, the Surprise member is locally thicker and contains more siltstone and sandstone passing laterally into diamictite.

Wright and others (1974) have suggested that the east-west trough represents a subsiding basin which could be an aulacogen. In the central Panamint Range, Labotka and Albee (1977) have proposed that deposition took place on a foundering shelf with islands providing local sediment sources. The presence of striated stones and dropstones at certain localities points to a glacial influence and the work in progress aims to elucidate the nature of this glacial association as well as the local paleogeography.

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THE STRATIGRAPHIC AND PALEOGEOGRAPHIC IMPORTANCE OF PALEOCENE AND EARLY EOCENE DEPOSITS IN BIG BEND NATIONAL PARK, TEXAS

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Paleocene and Eocene deposits in Big Bend National Park lie south of all other major Paleocene and Eocene terrestrial, fossil-bearing sites of North America. Prior to the middle Eocene, the Big Bend region was remote from sediment-source uplands in comparison to the more northern intermontane basins of Wyoming, Colorado, and New Mexico, which contain the world's largest and best studied terrestrial Paleocene and Eocene faunas. Long distance from the source uplands resulted in slower deposition, so that a large number of superimposed mammalian faunal zones can be recognized in relatively short sections in Big Bend. Faunal changes in Big Bend are more likely to have been caused by climatic changes or major population shifts spurred by the spread of new types than by tectonic changes, which strongly affected the intermontane sites.

Faunal and paleopedological evidence indicates that the Paleocene climate in Big Bend was semitropical to tropical with alternating wet and dry periods of greater than seasonal duration. Color banding in fluvial overbank mudstones, a soil-formed feature produced by changes in the height of the water table, is present in Paleocene and early Eocene rocks of Big Bend, but absent in early Paleocene rocks of Wyoming and Colorado. The spread northward as far as Wyoming of color banding at the end of the Paleocene traces a northward movement of subtropical climate. This warming would have made passage of terrestrial faunas between Europe and North America easier in the early Eocene than in the Paleocene. It partially explains why Big Bend Paleocene faunas show much less similarity to European Paleocene localities, which are similar in latitude, than early Eocene faunas of the northern intermontane basins show to European early Eocene faunas.

The area of development of many modern orders, such as the Rodentia, which appear in Wyoming and Colorado around the Paleocene-Eocene boundary, is not known. The evidence for a northward shift of warmer climate at this time suggests a southern source. A Wasatchian site in Big Bend National Park, at which screening for small mammal fossils began recently, has yielded mainly rodent specimens. Until more abundant mammal sites can be discovered for the early Tertiary of Mexico or the North American southeast, study of the Big Bend fossiliferous sequence offers some of the best available clues to affinities of the aminals marking the Eocene transition.

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THE CONTRIBUTION OF LILBURN CAVE TO THE NATURAL HISTORY OF SEQUOIA-KINGS CANYON NATIONAL PARKS

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Investigations in the Lilburn Cave System have included geologic and hydrologic studies of the cave's development, an examination of the cave's mineral and sediment deposits and its atmosphere, and preliminary biological surveys. This work adds an interesting new dimension to our understanding of the parks' features and their history.

Lilburn Cave is a 7.5 mile long maze of marble passageways which were formed by a cave stream system beneath the forest floor of Redwood Canyon. Current studies show that the groundwaters, during the course of their excavation, have followed rock fractures whose orientation was controlled by the geologic forces which shaped the Sierras in this region. The cave stream's resurgence at Big Spring displays a peculiar ebb and flow pattern, which is caused by the alignment of the natural plumbing system along these distinctive rock fractures. Even the cave's atmosphere reflects the geometry of the passageways, both in the appreciable, seasonally constant levels of naturally-produced radon gas in the cave air, and in the faithful response of the cave's carbon dioxide levels to the yearly cycle of biological activity in the forest soil.

One great value of caves lies in their qualities as peaceful, relatively undisturbed places which change only slowly through time. For example, the stability of the cave environment has permitted a fascinating array of unusual minerals to develop in Lilburn's corridors. Perhaps more importantly, as the forces of geology and climate altered Redwood Canyon over the centuries, Lilburn quietly recorded these events as banding in cave sediments, minute chemical patterns in dripstone and assorted debris left by furry cave visitors. The cave sediments reveal an earlier time when Redwood Creek more closely resembled a placid stream than the rushing mountain creek we see today. Chemical traces in the calcite speleothems testify to the cooler temperatures in the southern Sierras during the ice ages. Deposits of bones in the marble crevices are all that remain of former Canyon inhabitants.

The author acknowledges the work of all the investigators whose findings are summarized in this abstract.

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RUNNING SPRINGS: A LATE PLEISTOCENE-HOLOCENE FOSSIL COMPLEX ON SAN MIGUEL ISLAND, CALIFORNIA

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The Running Springs fossil locality on San Miguel Island continues to yield land vertebrate-botanical assemblages, and is proving to be one of the most important late Quaternary sites on the west coast of North America. Mammoth remains consisting of teeth, tusk and skeletal elements occur in abundance and are commonly charred and calcined. Monterey Pine (Pinus radiata) fossils occur as molds in calcareous tufa which is abundant and widespread in and around the springs. Cypress (Cupressus) charcoal is present and was recently discovered in direct stratigraphic association with charred and calcined mammoth in a hearth-like, fire-oxidized zone. Mammoth is extinct, and native Monterey Pine and Cypress do not presently occur on San Miguel Island.

Two radiocarbon determinations on the Cypress charcoal gave values of 16,520 ± 150 and 15,630 ± 460 radiocarbon years before present. These dates show that island mammoth and conifers persisted into terminal Pleistocene time on San Miguel Island, which was then the western portion of the Northern Channel Islands Platform (Santarosae). The disapperance of mammoth and conifers is discussed.

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POTENTIAL INSTABILITY OF RAINBOW BRIDGE NATIONAL MONUMENT, UTAH - A ROCK MECHANICS VIEWPOINT

ROGERS, J. DAVID

In mid-July 1979 the rising waters of Lake Powell will inundate the Kayenta sandstone foundations of Rainbow Bridge to a depth of over 35 feet. The Bureau of Reclamation and the National Park Service maintain that stability of the Bridge will be unchanged by inundation of the foundations. Opinions on the subject have been bantered about since Eugene LaRue, a USGS hydrologist, first visited the site in 1914. The case for potential instability and the need for proper instrumentation of the Bridge and its foundations will be made herein.

In-house federal investigations into the Rainbow Bridge foundation concluded that the Kayenta sandstone, the inundated member, was a "harder rock" than the overlying Navajo sandstone that makes up the scenic natural bridge. Although a small piece of Kayenta sandstone from this site has a higher compressive strength, the rock mass as a whole is much more fractured and discontinuous. The Kayenta's bulk moduli of elasticity and stiffness may be substantially lower than corresponding values of the overlying Navajo sandstone.

Rainbow Bridge is a delicate natural structure. Its immense size is derived from a never ending procession of interior stress redistributions creating tensional fractures and enhancing intact zones of compressional stress. The tensional breaks permit discrete blocks to spall off (a large block detached itself in May of this year). The classical interpretation that ancient Bridge Creek waters created the present stucture is a misnomer. The structure created itself, the Creek waters only initiated the process.

As Lake Powell rises, uplift forces beneath the thrust abutments of the arch will be created. These uplift forces will serve to perturbate the compressional stress field within the sandstone Bridge and could induce tensional fractures within the Bridge. If the highly fractured Kayenta foundation strains upon being bouyed by the lake waters piecemeal destruction of the Bridge will also result.

A thorough instrumentation program and an independent consulting board should be appointed by the Park Service: one test is worth a thousand expert opinions. The instrumentation should consist of a EDM triangulation network, piezometers, and a continuous borehole sampling of the site statigraphy as the existence of clay seams would be catastrophic.

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STUDY AND REMEDIAL SOLUTION FOR MT. CARMEL TUNNEL ZION NATIONAL PARK, UTAH

BENTLEY, FREDERICK W. HAMILTON, WAYNE L.

The Mt. Carmel Tunnel, completed in 1929 represented a bold achievement. Its design placed the 1.1-mile bore within a few meters of the face of a 200-meter-high cliff of jointed Navajo sandstone along the south wall of Pine Creek Canyon. The tunnel is famous for its windows, cut through the cliff face at galleries located at intervals along the bore.

The tunnel had only minor internal distress until 1958. On 28 April a 10,000 metric ton rock column broke away from the cliff above the window at Gallery 3. This rockfall ripped the steel-reinforced lining from the gallery ceiling, blocking the tunnel.

During repairs, strain gauges were installed in a new reinforced concrete rib where the outer rock wall thickness had been reduced to 0.3 meters. Gauges measure deformation at the top of the arch and vertical compression in the column adjacent to the cliff face. Stress in the concrete since 1960 has varied by approximately 0.3 to 0.8 kilopounds per square inch at both gauges, due largely to seasonal thermal stresses. These variations are superimposed upon a trend toward higher values of compression in the column, but not in the arch. Loading has increased, the highest value to date being 2850 psi.

This stress increase along with physical evidence of liner distress (cracking) has been of great concern and has generated a two phase design approach to correct possible tunnel structural damage.

Phase one provided for placement of a warning/stress monitoring system at Gallery No. 3 between January and May, 1979. The monitoring system consists of three rock movement measuring systems. The prime system is a series of nine extensometers placed in boreholes at the gallery. A battery powered electronic scanner is wired to each extensometer and provides a digital readout that records rock movement at each point in inches. Traffic warning signs are wired to the scanner and placed at the east and west tunnel portals. An arbitrary threshold rock movement of .0135" has been set to activate the warning signs. The secondary mechanical systems are Whitimore and convergence points placed in the gallery area.

Phase two will involve detailed inspection throughout the tunnel plus study and selection of design alternatives including: (1) Permanent road closure and relocation, (2) Removal of rock overburden with explosives, (3) Tunnel realignment at Gallery No. 3, (4) Reinforcement/Rock bolting, and (5) Total new tunnel alignment.

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EVIDENCE OF CATACLYSMIC EROSIONAL EVENTS IN THE GRAND CANYON OF THE COLORADO RIVER, ARIZONA

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Gigantic slump blocks, river anticlines, toppled crystalline rock slopes, and travertine deposits found in the Grand Canyon may be interpreted as testimony to the former existence of a large lake within the confines of the Canyon. The lava and/or pyroclastic dams responsible for the river impoundment(s) may have met sudden ends with overtopping and subsequent removal by hydraulic cavitation. There is evidence in the channels of the western Canyon that sudden changes in river base level took place. These may be explained by dam breachment in conjunction with the accepted hypothesis of tectonic shifting of the local crustal blocks.

Slump blocks of stratigraphically intact Paleozoic sediments have been noted in the vicinity of Surprise Valley. The volume of this slide mass is something over 5.5 billion cubic yards. Vertical displacement amounts to 1500 feet off of the North Rim of the Canyon. The blocks appear to have rotated along classical semi-circular slip surfaces with the critical shear resistance lying within the Bright Angel Shale. The upper part of the slide plane appears to be joint controlled and only frictional resistance along intersecting joint planes is assumed. Shear failure of the Bright Angel Shale under the known overburden can be analytically demonstrated. A drop in shear strength corresponding to a pore pressure rise induced by a rapid drawdown of an ancient Canyon reservoir seems to be a likely cause. Static analysis including river undercutting yields safety factors in excess of unity (using strength values derived in other parts of the Canyon).

The long recognized river anticlines along the Colorado channel between Kanab and Stairway Canyons can also be explained by the release of elastic strain energy within the Bright Angel Shale. Elastic strain release could have been generated by a rapid downcutting of the channel--either by enormous flood quantities or by the breachment of a volcanic dam some 8 to 20 miles downstream. Since this erosional episode the channel has been aggrading. Preferential directionality of the anticlinal structures is the result of destressed zones along directions of pre-existing discontinuities. A complicating factor may be directional anisotropy of available strain energy within the shale.

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MASSIVE ROCK TOPPLING IN GRAND CANYON, ARIZONA

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Rock toppling is a recently advanced explanation for large flexural failures of steeply oriented and well-jointed rock masses. Toppling failures with volumes in excess of 240,000 cubic meters were recognized at Clear Creek in 1976, the largest yet-documented in the world. These toppling failures serve to break up and transmit huge volumes of crystalline basement rocks into the Colorado River channel, thereby facilitating an accelerated mass-wasting cycle.

In 1978 the topples on the west side of Clear Creek were mapped, samples were taken of the schist, and carbon samples were taken from perched alluvial deposits 70 feet above the river channel. In the course of this study two new types of rock toppling were discovered; buckling topples and load-deformation topples. More extensive areas of toppling were also noted in Travertine and Waltenberg Canyons. All of the toppling modes recognized in the schist can be attributed to the steep downcutting of the river system. Many of the topples appear to be of late Pleistocene age, and subsequent analysis should be able to provide ages of the failures with respect to former river channel elevations.

The large topple at Clear Creek was mapped by means of color terrestrial photogrammetry with surveyed triangulation control. A sizable in-situ sampling program was initiated to obtain representative samples of the Vishnu schist for shear testing along joint and foliation planes. Appropriate friction values were then used in a three-dimensional finite-element computer model of the failed mass. Previous channel and phreatic levels can be manipulated to recreate the morphology of the Canyon at the inception of failure (by limit equillibrium analyses). Average values of channel downcutting derived from the carbon samples are used to approximately date these massive rock slope failures.

Careful geotechnical analyses may provide a window for dating features within the Grand Canyon. In doing so the dates of ancient Colorado River levels and the presumable phreatic levels within the Canyon rock formations can also be ascertained.

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FRESHWATER FLOW DETERMINATION WITHIN THE SHARK RIVER SLOUGH, EVERGLADES NATIONAL PARK

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The Shark River Slough is the largest natural drainageway within Everglades National Park containing 142,000 acres of wetlands. Surface water flows in a southwesterly direction originating from controlled sources at Everglades National Park's northern boundary and from precipitation which falls directly in the slough. A portion of the Shark Slough fresh waters eventually enters Everglades National Park's brackish estuaries. The fauna and flora within the slough have adapted to the seasonal hydroperiod and water depth and the inhabitants of adjacent estuaries have adjusted to salinity regimes which are dependent on freshwater inputs. In order to manage this resource it is necessary to understand the flow dynamics within the marsh so that adjustments can be made to delivery sites external to the park. Flow rates are less than 0.17 fps (5.2 cm/sec) discounting the use of conventional velocity instrumentation and suggesting the application of tracer dye studies. Field tracer dye experiments were conducted in 3 hydrobiological zones, representing tall vegetation, open marsh, and intermediate vegetation zones, within which velocities from 0 to 0.07 fps (2.1 cm/sec) were measured. Repetition of these experiments on an annual hydroperiod cycle allowed these velocities to be related to variable water levels with the subsequent construction of stage/velocity hydrographs. In-slough velocities coupled with seasonal cross-sectional measurements, allowed for flow rate computations which were related to measured flow rates at control structures external to the park. The measurement of slough velocity coupled with hydraulic depth and slope also provided an understanding of Manning's roughness coefficients for this marsh.

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APPLICATION OF LANDSAT MULTISPECTRAL IMAGERY TO DETERMINE THE SPATIAL AND TEMPORAL ASPECTS OF SURFACE WATER DISTRIBUTION IN THE SHARK RIVER SLOUGH, EVERGLADES NATIONAL PARK

ROSE, PAUL W. AND PETER C. ROSENDAHL

The Shark River Slough serves as the major arterial for surface water movement in Everglades National Park. The slough is dependent upon allocations of freshwater in sufficient quantity and at appropriate rates to approximate historic hydrologic conditions. A comprehensive analysis of the spatial and temporal impact of water released through the control structures is required in order to better preserve and maintain the park's ecosystem. LANDSAT multispectral imagery provides the capability to develop a multivariant synoptic analysis of the water distribution throughout the "wet" and "dry" seasons in the slough. These investigations have given greater insight into seasonal areas of inundation in the Shark Slough and will enhance the water resources management program for Everglades National Park.

The research employed was systematic establishing ground truth with aerial photography and hydrologic data collected at various monitoring locations throughout Everglades National Park corresponding with LANDSAT overflights. Multispectral reflectance characteristics of the Shark Slough were determined utilizing a supervised interactive processing technique accomplished on a G.E. I-100 classifier. These results were then directly applied to LANDSAT multispectral imagery. The spectral gray level variance/distribution for areas inundated by surface waters in the slough were analyzed for each LANDSAT MSS-band. Likewise, the dry areas in the slough were analyzed. The spectral dissonance between the two zones defined the margins of the slough for a given hydrologic condition and period of time. Subsequent iterative procedures were then employed for the various LANDSAT overflights throughout the "wet" and "dry" seasons so that a hydrographic delineation of the slough's margins could be generated. These investigations have provided utility in establishing spatial and temporal aspects for the margins of the Shark Slough which will be of significant value to future hydrologic research in Everglades National Park.

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DEEP SECRETS AND DARK PROBLEMS; STUDIES OF KARST SPRINGS IN THE OZARK NATIONAL SCENIC RIVERWAYS.

ALEY, THOMAS* and DAVID I. FOSTER**

Most of the water in the Ozark National Scenic Riverways is discharged from large karst springs. These springs drain extensive karst areas outside the Riverways boundaries. Unfortunately, these spring systems are readily subject to contamination, and this poses a serious threat to the integrity of the springs, their aquatic life, and the health of the tens of thousands of visitors who drink from the springs under the erroneous conviction that spring water is pure water.

Through a groundwater tracing program begun in 1967, we have been delineating the recharge areas for a number of the most significant springs in the Riverways area. Water has been successfully traced underground for as much as 40 miles straightline distance; mean travel rates for this water can be as rapid as several miles per day.

Because of interaction between land use and the hydrologic functioning of particular sites, certain areas represent particularly significant threats to the water quality of spring systems. We have developed a program for identifying, evaluating, and mapping these "hazard areas".

Many of the identified hazard areas are regions where water can move rapidly (and without effective natural cleansing) from the surface into spring systems. These include sinkhole areas, losing streams, and areas on or near identified lineaments. Land uses which represent particular hazards include sewage disposal facilities, dumps, landfills, salvage yards, industrial sites, transportation routes and pipelines, petroleum and chemical storage sites, and agriculture (primarily beef production on permanent pasture).

Our hazard area evaluation integrates physical features of the site (e.g., presence of sinkholes, losing streams, and proximity to lineaments) with actual and projected land uses. This permits Park Service concern to be focused on those areas where groundwater quality problems are most likely to occur, and where problems are most likely to be severe.

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KARST HYDROLOGIC STUDIES IN THE MAMMOTH CAVE NATIONAL PARK AREA, KENTUCKY: TECHNIQUES, RESULTS, AND ENVIRONMENTAL APPLICATIONS

QUINLAN, JAMES F.

The major techniques used are: water tracing, mapping of the piezometric surface, cave mapping, radio location of drill holes for observation wells, and monitoring of water quality, precipitation, discharge, and water levels.

The following have been successfully used as tracers: 1) heavy metals (Ni, Cr, Cu, and Zn) in industrial effluent discharged into a sinkhole, 2) optical brightners, both introduced and in sewage plant effluent, 3) Direct Yellow No. 96, 4) fluorescein, and 5) Rhodamine WT. Optical brightners and Direct Yellow are identified by ultra-violet irradiation of cotton detectors. Fluorescein and Rhodamine WT are identified by sorption onto charcoal detectors and examination of elutant in sunlight. New tracer techniques involve use of optical brightners, Direct Yellow 96, and a simple reading glass to increase the limit of visual detection of fluorescein by more than 2 orders of magnitude to 1 ppb.

A piezometric map, based on measurement of 1200 water wells, compliments the dye-tracing data and is used to plan additional dye tests. A special radio transmitter has been used to locate holes to be drilled to intercept large cave streams at depths of up to 40 m. Water-level recorders have been installed on these wells.

The use of these techniques has made it possible to determine the source of spring waters, delineate groundwater basins, and understand flow within the limestone. Water from numerous sinking streams has been traced as much as 24 km via as many as 3 caves and karst windows. Most flow is through a dendritic system of conduits that feed trunk streams that are commonly 15 m wide and in which water levels may rise as much as 30 m in response to heavy rains. Velocities range from 10 to 400 m/hr. Twelve of 14 groundwater basins are also characterized by discharge from springs with a distributary flow pattern 50 m to 4 km wide. One of them, the Hidden River Groundwater Basin, discharges heavy metal-rich water at as many as 46 springs at 16 locations along an 8 km reach of Green River. One of these springs was excavated and more than 30 km of distributary and floodwater-maze cave passages has been mapped.

The dye-tracing results are being applied to: 201 planning for regional sewage disposal, protection and interpretation of resources at Mammoth Cave National Park, protection of groundwater supplies, and industrial development in the surrounding region.

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WATER QUALITY ANALYSES OF THE COLORADO RIVER CORRIDOR OF THE GRAND CANYON

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Field water quality analyses of the Colorado River corridor of the Grand Canyon were conducted from April through September, 1978 and in July and August, 1979. Analyses were designed to establish a baseline water quality profile of the Colorado River and its Canyon tributaries. As the premier recreational white water river in North America, access through the 225-mile Colorado corridor was by raft in a series of eight 14-day float trips. Approximately 14,000 people each year float the Canyon, relying on the river as a source of drinking, bathing, and dishwashing water; at times as a garbage disposal; and as a carrier of rafts. Associations between river runner use of the Canyon and water quality conditions were a management concern examined by the research.

During the 1978 field season, two sample designs, a time-series and a fixed location format, sampled 31 side creek sites and approximately 90 river locations per trip. Emphasis was placed on the measurement of fecal coliform and fecal streptococci concentrations, bacterial groups which are indicators of recent human and warm-blooded animal fecal contamination, in both surface water and bottom sediment environments. Selected physical and chemical water quality parameters were also routinely sampled.

Several key technical field water quality analysis problems were approached by the research that included field bacterial analysis of highly turbid natural waters and bottom sediments. A portable vacuum manifold filtration system was designed to permit efficient and accurate processing of large numbers of samples. Three techniques using combined membrane filter (MF) and most probable number (MPN) and reliable field incubation were developed to accommodate the research. Preliminary results show bacterial concentrations in side streams and the river sufficiently high to warrant management concerns.

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CHEMICAL COMPOSITION OF SELECTED WATER SOURCES WITHIN GRAND CANYON NATIONAL PARK

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The chemical composition of fifteen Grand Canyon water sources has been determined by routine chemical and atomic absorption spectrophotometric procedures in an attempt to correlate the chemical composition of the water samples with the geologic origin of the water. Very significant chemical differences occur between all water samples studied, and it is possible to identify a particular water sample from its chemical "fingerprint".

The chemical species determined in each sample include: calcium, magnesium, sodium, potassium, carbonate, sulfate, chloride, nitrate, hydroxide, iron, copper, chromium, nickel, vanadium, cadmium, zinc, lead and manganese. The most significant variable affecting water chemistry appears to be water volume, with the high north rim creeks displaying a significant dilution effect over similar water samples collected from south rim sources. The data from some selected creeks are as follows:

Source	Ca^{1}	Mg^{1}	K^{1}	Na^{1}	$Hardness^{2}$	HCO_3^{-2}	SO_4^{2-1}	Cl^{-}	$D.O.^{1}$
Boucher	105	69.5	9.9	59.1	531	284	248	90.0	6.4
Monument	125	129	16.2	151	843	227	556	259	7.2
Salt	111	214	22.4	57.4	1159	207	52	62	6.2
Pipe	99	106	31.6	73.3	686	2.6	435	129	8.6
Thunder	32	11	0.6	1.2	125	133	4	13.5	10.5
Tapeats	32	10.5	0.8	3.1	123	146	5	42	10.3

The changes occuring in water chemistry as a creek flows from its source to the Colorado River have been documented for Bright Angel Creek. The data for four sampling sites along Bright Angel Creek are as follows:

Sampling Site	Temp.	pH	D.O.	HCO_3^{-2}	$Hardness^{2}$	K^{1}	Na^{2}	Cl	SO_4^{2-}
Roaring Spring	13°	8.0	7.2	276	152	0.7	ND	ND	ND
Cottonwood C.G.	18°	8.0	9.0	290	170	1.2	ND	ND	ND
Ribbon Falls	17°	8.1	8.8	336	192	1.1	ND	ND	30
Phantom Ranch	19°	8.2	8.8	359	211	3.5	3.7	ND	30

1) Expressed as mg/l (PPM).
2) Expressed as mg $CaCO_3$/l.

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PHYSICAL AND CHEMICAL CHARACTERISTICS OF STREAMS IN GREAT SMOKY MOUNTAINS NATIONAL PARK

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Most of the Great Smoky Mountains National Park (GRSM) is underlain by insoluable sandstones, although there are also limestone areas, areas of highly acidic rocks (Anakeesta), and several other less dramatic formations. A one-year study was begun in the fall of 1977 to assess the water quality of streams in the Park with possible relation to these factors as well as elevation and forest type.

Water samples were taken from streams in all areas of GRSM and analyzed for pH, conductivity, alkalinity, hardness, turbidity, nitrate concentration, fecal coliform, fecal streptococcus, and total coliform bacteria. Temperature and flow measurements were also made. Each station was sampled quarterly to look at seasonal variation, and two stations were sampled daily to assess shorter term variability. Results were correlated to vegetation, geology, past and present human disturbance, and elevation of watersheds, as well as season and weather conditions. Only the more generally significant findings are presented here.

Nitrate concentrations were found to be controlled almost exclusively by elevation and past logging history. Watersheds which had been logged prior to establishment of the Park showed much lower nitrate concentrations than those never exposed to extensive logging. High elevation streams had much higher concentrations than those at low elevations. Concentrations ranged from near zero in low elevation logged areas to over 5 mg NO_3/l in high elevation unlogged areas.

Other chemical parameters were affected primarily by geology and elevation. Conductivity was generally below 20 μmhos/cm^3, alkalinity and hardness below 10 mg/l (as $CaCO_3$) and other parameters at similarly low levels except where influenced by limestone or other carbonate-containing rocks. Water was much more acidic in high elevation streams, decreasing at a rate of approximately 0.3 pH units per 1,000 ft. elevation. Concentrations of most mineral constitutents reversed at both high and low elevations; lowest values were found at middle elevations.

Bacterial counts, though high in some heavily used areas, seemed to be affected primarily by water temperature. The highest counts were found in summer and at low elevations.

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WATER CHEMISTRY OF THE REDWOOD CREEK AND MILL CREEK BASINS, REDWOOD NATIONAL PARK, CALIFORNIA

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A 2-year study was made in the Redwood Creek and Mill Creek drainage basins of Redwood National Park to determine existing chemical water-quality conditions and to identify the effects of logging on water quality in the main stems and tributaries of the two basins.

Overall, the chemical water quality of the main stems and the tributaries is excellent, suitable for most beneficial uses. Dissolved-solids concentrations range from 25 milligrams per liter in the Redwood Creek basin and 21 milligrams per liter in the Mill Creek basin during the rainy season to 139 and 49 during the dry season. Water shifts from a mixed calcium-sodium bicarbonate-chloride type toward a calcium bicarbonate type from the end of the wet season to the end of the dry season. It shifts back toward a mixed calcium-sodium bicarbonate-chloride type from the end of the dry season to the end of the wet season. The pH shifts with the water type from a median value of 6.80 in the rainy season to 7.37 in the dry season.

Evidence suggests that dissolved calcium and bicarbonate in stream water is produced by weathering of the Franciscan assemblage underlying the basins but that chlorides are transported inland from the ocean as dry fallout and spray and in rain. Exposure of the surface soils to the elements, either by logging or by natural causes such as sparse vegetation, seems to accelerate weathering, which leads to a calcium bicarbonate water type. Logging accelerates weathering most in the tributary watersheds with regoliths derived from sandstone and least in those with regoliths derived from schist; however, the data suggest that the rate of weathering in a schistose watershed can increase dramatically if soil disruption is extensive.

Studies during storms indicated that specific conductance and alkalinity were two to three times as likely to decrease at the discharge peak in logged watersheds as in forested ones. This suggests that overland flow containing lower concentrations of soil-derived dissolved solids than flow from other sources is a larger component of peak flow in logged watersheds than in forested watersheds.

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OPTICAL PROPERTIES OF CRATER LAKE, OREGON: VARIATION IN SECCHI DISK TRANSPARENCY, 1937-1979

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Crater Lake, Oregon, the deepest lake in the United States at 589 meters, is famous for being one of the clearest lakes in the world. Secchi disk transparency measurements--indicating the degree of lakewater clarity--were 36, 39 and 40 meters on three separate days in August, 1937. Only one other lake in the world, namely caldera Lake Masyuko in Japan, featured a greater recorded Secchi depth (41.6 meters).

Since 1937, the Secchi disk transparency of Crater Lake has tended to decrease. Secchi readings during the summers of 1968 and 1969 averaged 35.4 meters (range: 31-39 meters) which was about three meters less than the 1937 average. During the summer of 1978, the average Secchi disk reading for seven measurements was 29 meters (range: 28-30 meters). This value, representing a reduction in lakewater clarity of about 25% since 1937, suggests that the lake has become less transparent due to an increase, perhaps, in the amount of suspended particulate matter capable of scattering sub-surface light and reducing Secchi transparency, or visibility. The nature of the particulate matter is not known--assuming that that is the source of the problem--but it is possible that the lake has become more productive biologically as the result of subtle increases in algal nutrients or water temperature. Either factor, singly or in combination with one another, could conceivably increase phytoplankton biomass which is often the cause of reduced Secchi transparency in lakes.

The extent to which incident solar radiation is transmitted in Crater Lake, as determined in vertical profile to a depth of 100 meters with a submarine photometer, appears to have diminished also in the years between 1968 and 1978-79.

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GEOHYDROLOGIC STUDIES - INDIANA DUNES NATIONAL LAKESHORE, INDIANA

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The Indiana Dunes National Lakeshore is in an environment that ranges from heavy industrial to rural. It shares common boundaries or is close to major steel companies an electric power-ternerating company, Northern Indiana Public Service Company (NIPSCO), several cities, small towns, and a State park. The National Lakeshore contains marshes, interdunal ponds, and Cowles Bog, a national landmark.

In 1974, NIPSCO began dewatering at the construction site of a nuclear powerplant, and a slurry wall was subsequently installed around the site in an attempt to limit the dewatering effect on ground-water levels in the National Lakeshore area. NIPSCO also operates a series of settling ponds to accumulate fly ash derived from coal burned for generating electricity.

In 1976 the National Park Service requested the U.S. Geological Survey to undertake a 2-year study to determine the effect of the construction-site dewatering the settling-pond seepage on ground-water levels in the National Lakeshore area.

Simulation results from a multilayered digital aquifer model constructed in 1978 indicates that 2 million gallons of water probably seeps daily from the settling ponds to the ground-water system. As a result of the seepage, ground-water levels inside the park boundary have risen as much as 10 feet, thus changing some marshlands into interdunal ponds. The simulation also indicates that the construction-site dewatering probably has lowered ground-water levels in the lakeshore area by 3 feet or less.

To further understand the geohydrology of the National Lakeshore and its surrounding area a comprehensive study is being made by the U.S. Geological Survey in cooperation with the National Park Service. Holes will be drilled to depths of approximately 200 feet to determine the characteristics of the deposits. Observation wells will be installed. Ground-water pumpage will be identifed and the interaction between ground water, marshes, ponds, and streams will be determined.

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EFFECTS OF COAL FLY-ASH DISPOSAL ON WATER QUALITY AT THE INDIANA DUNES NATIONAL LAKESHORE, INDIANA

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Seepage from two unsealed fly-ash settling ponds bordering part of the Indiana Dunes National Lakeshore increased concentrations of dissolved B, Mo, SO_4, K, and gross α and β radioactivity in Lakeshore water resources. Although concentrations of dissolved As, Al, Cu, Cd, Co, Ni, Sr, Zn, Fe, Pb and suspended gross α and β radioactivity in the settling ponds were variable and generally higher than those of other local surface waters, they were reduced by the soil system of the dike separating the settling ponds from the Lakeshore. Concentrations of As, B, and Sr exceeding background concentrations in waters adjacent to a leached fly-ash landfill suggested continued leaching of these elements from the fly-ash particles.

Sorption, chemical precipitation, and organic complexation are probably responsible for retaining elements in the dike. A section of the dike underlain by an organic stratum seemed especially effective in retaining trace metals. Because of predominantly anionic forms of B, Mo, and S, and the low charge density of K, these elements were not efficiently removed by the dike. Major amounts of α and β radioactivity were probably due to U^{238} and K^{40}, respectively. Increased suspended particulates due to traffic on the generating station access road seemed to increase atmospheric chemical loading to the bordering area. However, atmospheric fallout was not a major source of chemical loading in the study area.

Established water-quality criteria and results of various bioassays indicate that As, B, and Mo in settling pond seepage and B in ash-fill leachate could pose plant-toxicity problems. Cd and Zn periodically in settling-pond seepage could be toxic for some aquatic animal life. Although other potentially hazardous elements seem to be controlled, biological activity and water chemistry changes could result in redissolution and increased availability of these elements to park flora and fauna.

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SALT INTRUSION AT PINHOOK BOG, INDIANA DUNES NATIONAL LAKESHORE

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The water chemistry of Pinhook Bog in northwestern Indiana reflects ombrotrophic (ion-poor) conditions consistent with peatland receiving precipitation as its primary water source. The operation of an uncovered road-salt storage area adjacent to the bog along Interstate 80-90 from 1963 until it was covered in 1972, resulted in dissolved sodium chloride reaching the bog through limited surface runoff. Continued salt use on the highway during the winter and loading operations at the storage area still contribute salt-water runoff to the bog. This alteration of water chemistry in the southern portion of the bog adjacent to the salt pile and highway has caused the death of native bog vegetation and allowed the invasion of more salt-tolerant cattails. Sampling of surface water, interstitial sphagnum mat water, and water from beneath the mat has identified the localization of salt contamination, showing a correlation with the areas of vegetative death.

Drive point wells screened in the open water beneath the mat and wells screened within the sphagnum mat were placed along a north-south transect from the salt-storage area through the center of the bog. Sampling was conducted on a bi-weekly basis for parameters which included: temperature, specific conductance, salinity, pH, acidity, alkalinity, chloride, sulfate, sulfide, calcium, and magnesium. Values for specific conductance, salinity, and chloride decreased at distances further from the salt pile. Buffering capacity as determined by alkalinity and acidity was also more characteristic of an ombrotrophic bog at greater distances from the salt pile.

The intrusion of salt appears to be localized at two levels. Beneath the sphagnum mat, salt concentrations are elevated, but not to the extent noted within the mat. The salt contamination beneath the mat also extends considerably less distance along the transect line than it does within the mat. The edge of the area of dead vegetation coincides with the transect point marking the zone of elevated salt concentrations within the mat. It therefore appears that migration of salt-water has occurred primarily within the sphagnum mat, and this is the determining factor controlling vegetative change, rather than migration of denser salt water at bottom elevations beneath the mat.

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RELATIONSHIP BETWEEN SOME PHYSICAL PROPERTIES AND THE VEGETATION FOUND IN COWLES BOG NATIONAL NATURAL LANDMARK, INDIANA

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So that one significant wetland might be properly characterized, we undertook to measure certain qualities of the water, vegetation and humic materials.

Hardwood swamp forest within the wetland coincides in location with a clay layer that is present under a 6 meter thick layer of peat. Where this clay pan terminates and a sand mineral bottom is present under the humic material, other vegetation is present. Most notably, the latter is cattail which forms quaking root mats. In another case, northern white-cedar is located on an elevated mound of humic soil under which the ground water has a positive hydrological pressure.

The groundwater is highly mineralized and of nearly neutral acidity. There is controversy whether this represents the native condition or is due to change induced by nearby industrial activity. Only one early (1922) water quality assessment is known, and it is consistent with that found today. Similarly, the vegetation present, especially the northern white-cedar, red osier dogwood, speckled alder, willow and swamp birch all speak to the long term presence of water quality characteristics similar to those found today.

Tree size restricts longevity because trees are unstable in the very loose humic soil and subject to windthrow. This circumstance has helped crowd the less shade tolerant species to the swamp-cattail ecotone. Some seedlings of eastern larch and white pine are present in the cattail mat but these give doubtful promise of perpetuating the species; some observation suggests that fire could give advantage to the conifers.

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NEUTRALIZATION OF ACID RAIN AND NATURAL WETLAND ACIDS IN THE PICTURED ROCKS AND ISLE ROYALE ECOSYSTEMS

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The neutralization of relatively strong acids, resulting both from acid rain and natural wetlands, occurs rapidly in undisturbed drainages apparently by reaction primarily with aluminum salts occurring in the soil profiles.

Early results indicate a rather extensive occurance of acid rain in the Lake Superior Basin. Most drainages into Lake Superior also contain wetland areas. Despite the occurance of such sources of acid major drainages from Isle Royale National Park and the Pictured Rocks National Lakeshore are not excessively acid upon entrance into Lake Superior. In all cases, except for recently disturbed drainages, pH values are considerably lower in the smallest headwater streams rapidly increasing downstream. This reflects the input of atmospheric and wetland acids. pH values can increase dramatically in short distances downstream depending upon the nature of the soil and bedrock encountered.

This rapid neutralization of acids once precipitation reaches the forest floor does not prevent damage to the forest canopy, the accompanying lichen community, or the herbaceous layer. The changes in quality and quantity of precipitation as it passes through these biotic layers indicates the need to more closely examine the impact of acid precipitation on the attached lichen community.

Acid neutralization is but one component of more extensive biogeochemical analyses underway in these ecosystems. The first year's data are preliminary but when combined with sixteen years of Geological Survey baseline hydrological data indicate the direction of change for some important plant nutrients and also the status and functioning of these ecosystems.

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SOCIOLOGY

DETERMINANTS OF THE QUALITY OF NATIONAL PARK INTERPRETIVE SERVICES: A CASE STUDY OF GETTYSBURG NATIONAL MILITARY PARK, PENNSYLVANIA.

KNOPF, RICHARD C.

A consumer analysis of 631 visitors to Gettysburg National Military Park was designed to create managerially useful information on determinants of visitor satisfaction. The research was initiated and sponsored by the Eastern National Park and Monument Association to identify (a) specific outcomes desired by Park visitors, (b) visitor evaluations of physical and social attributes of the Park setting, (c) visitor orientation needs, (d) existing patterns of interpretive services usage, and (e) relative performance of specific interpretive programs in enhancing visitor knowledge and experiences.

The focus of this paper is to identify factors which affect performance of the Park's system of interpretive services. The basic dependent variable is level of attained knowledge about Gettysburg history. Discriminant analysis is employed to identify demographic, perceptual and behavioral variables which best discriminate among park visitors differing in level of attained knowledge.

Differences between groups were found not only in the nature of interpretive programs visited, but also in the order in which they were visited. For example, those who made use of the auto tour before visiting one of the Park's two interpretive centers perceived less understanding of Gettysburg history than those who made use of the same opportunities, but in reverse order. Further, if both interpretive centers were visited, attained knowledge differs depending on which center was visited first. The data clearly suggests synergistic effects among different components of the interpretive system at Gettysburg. Theoretical rationale to explain study findings is presented, together with a discussion on the value of ordering visitor exposure to different forms of information.

Other variables found to be significantly associated with information transfer include relative accessibility of park personnel, judged authenticity of park exhibits, and degree of congestion in interpretive areas. Implications of these site-specific findings in Gettysburg to the management of interpretive systems in general are offered.

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VISITOR AND STAFF PERCEPTIONS OF NPS VISITOR CENTERS

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A study of National Park Service Visitor Centers was undertaken for the Denver Service Center in 1975 for purposes of developing information that can contribute to more enlightened and informed visitor center design decisions in the future. To determine what constitutes a successful center, certain aspects were anlayzed, such as spatial and functional relationships, maintenance issues, safety and security, the relationship of the center to its surroundings, visitor and staff perceptions of quality of the center, visitor patterns of use, building site selection procedures, and team design responsibilities.

The study employed a conceputual evaluation model consisting of the setting, including the structure and its immediate surroundings; the context, including the broader physical and thematic environment; the users, including visitors and park staff; and the design activity, including how and by whom design decisions are made.

This paper discusses one aspect of the study, the users--both visitors and park staff. Questionnaire data from 3065 visitors and 150 park staff at 12 visitor centers within the continental United States are analyzed to assess the quality of arrival areas, building exteriors, interiors and exhibits. Perceptions of visitors and staff are compared and differences in perceived quality are discussed.

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VISITATION TRENDS IN YOSEMITE NATIONAL PARK

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As with many national parks, visitor use in Yosemite has increased dramatically during the past 20 years. Since 1968, however, use has leveled off to an average of 2.4 million visits per year. Coincident with this delcine in the growth rate, there have been some changes in visitation trends and patterns. Data collected in 1953, 1968, 1973, 1975, and 1977 show that the average length of stay has decreased to about 27 hours and that the average number of visitors per vehicle has dropped to slightly less than three. Although more people are visiting Yosemite each year, they are staying for shorter periods of time and in smaller groups than in the past.

The 1977 survey was conducted for 12 months, while the previous surveys collected data only during short periods in the summer. Analysis of the 1977 data showed that the number of visitors per car did not vary significantly from month to month or between entrance stations. Length of stay was affected by the station entered and exited. Day users traveling in either direction between the Big Oak Flat entrance on the western boundary of the Park and the Tioga Pass entrance on the eastern boundary were in the Park less than four hours, indicating that these visitors used the Tioga Road as a trans-Sierra highway. The average length of stay for visitors entering Tioga Pass was 19 hours, or 30 percent less than for all four entrances combined. Use of the Big Oak Flat entrance increased after 1968 when a new entrance road was built. It now contributes nearly 25 percent of the entries, while in 1968 only 14 percent of the vehicles entered there. Management programs must be adjusted to meet these changes in use trends. Day-use and other short-term visitors have different needs than visitors who stay for longer periods of time. Interpretive programs should be designed to reach these visitors, and more picnic areas should be developed for their use.

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DISPERSED WINTER RECREATION USE IN THE BADGER PASS BACKCOUNTRY OF YOSEMITE NATIONAL PARK

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Dispersed winter recreation in Yosemite National Park has experienced rapid growth during the past ten years. This growth, manifested by the ever-increasing popularity of ski touring, is centered in the Badger Pass backcountry. With the increased interest in dispersed winter recreation, Park managers need accurate and comprehensive visitor use data.

Surveys of backcountry visitors can be valuable tools in meeting the formidable challenges of National Park management. Visitor use studies provide an avenue towards determining carrying capacity values for heavily used areas. Due to recent increases in dispersed winter recreation use in the Badger Pass backcountry, Park managers have been presented with many new opportunities and difficult problems. The results of the study have provided a foundation for area-wide planning and a contextual framework for the current Yosemite Master Plan process.

The study was conducted to develop a base of information and improve the understanding of the rapidly expanding dispersed winter recreation situation in the Badger Pass backcountry. Self-administered questionnaires were distributed to a sample of 330 overnight and day visitors. The respondents were contacted as they finished their backcountry trip at two interview sites.

Study findings were divided into five sections: (1) visitor profile; (2) visitor trip characteristics; (3) impact problems encountered by the visitor; (4) attitudes of the visitors regarding existing and potential management practices--ski huts, winter trails, and trail markers; and (5) preferences of the visitors in relation to access and parking.

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NATURE AND EXTENT OF DIFFERENCES BETWEEN ACTUAL AND PLANNED BACKCOUNTRY USE IN SEQUOIA AND KINGS CANYON NATIONAL PARKS

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Wilderness permits measure planned rather than actual backcountry visitor use in as much as the permits are filled out prior to taking a backcountry trip. However, while the nature and extent of the difference between planned and actual use can be an important input to management decisions, its understanding to date has been primarily the subjects of "expert" judgment and informal studies. The objective of this study was to develop and implement a scientific random sampling plan to collect information on the nature and extent of the difference between actual and planned backcountry visitor use. Results indicated some major differences between planned and actual backcountry use for Sequoia and Kings Canyon National Parks and pointed to several improvements that could be made to the sampling plan.

Fourteen trailheads were selected for the main study. These trailheads accounted for 70.1% of total backcountry use in the previous year as measured by wilderness permit data. The study was conducted over a six day period in August.

All visitor groups exiting the Parks were questioned about their actual visit to the backcountry by a uniformed Park employee. Approximately 520 groups were interviewed on the trail just before exiting at a trailhead. The temporal and spatial changes in the visitor's planned trip were recorded.

Results of the study indicate that permits tend to overestimate visitor use. For example, actual visitor nights were 80.2% of that indicated on the permits. Actual length of stay was 89.2% of projected and the actual number of people was 91.6% of projected. On the average, each group of 100 permits overreported backcountry visitor use by 371 visitor nights, 28 people, and 55 nights.

On the average, permits that were issued through reservations had more overreporting of visitor nights, less overreporting of length of stay, and more overreporting of visitor group size than permits issued without reservations.

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DESIGN, STRUCTURE, AND BEHAVIOR AT CRATER LAKE NATIONAL PARK

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Despite widespread agreement that environments affect people, little is known about how specific environmental elements influence behavior. A theory developed here integrates work in psychology and environmental design, describing the connections among structure, perception, behavior, and experience. The theory is illustrated by visitor behavior at Crater Lake National Park in Oregon. Rim Village, the center of visitor activity, was divided into areas depending on structural characteristics. Observations of visitor behavior show that parking patterns, uses of rim areas, activities within the cafeteria complex, and times spent in different areas are all non-random. The experimental closure of a parking lot was evaluated in relation to these baseline data. Distribution of use changed dramatically, more than doubling the use of interpretive facilities (among other changes). Behavior patterns apparently are affected by structural characteristics, so redevelopment plans should be changed to encourage the kinds of experiences that managers would like to provide.

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SOCIAL AND ENVIRONMENTAL FACTORS INFLUENCING BEACH RECREATION IN URBAN PARKS

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Planners working in urban parks are charged with providing the maximum number and variety of land uses for widely differing cultural preferences of the urban region given limited physical resource bases. These constraints require a critical evaluation of the management program to adjust the best possible land use to each of the different management units of urban parks. The purpose of this study is to look at similarities and differences between beach use in two major urban parks, Gateway National Recreation Area, in the New York metropolitan region, and Golden Gate National Recreation Area, in the San Francisco metropolitan region.

The objective is to determine to what extent the physical environment and the cultural preferences of the user groups determine beach use. The physical constraints include the geologic setting, air and water temperature, climate, wave regime, beach characteristics, sediment sources, pollution, and air and water quality. Cultural preferences include the type of recreation preferred, the perception of beaches and beach use, knowledge of other recreational opportunities, access to recreation and a range of socio-demographic determinants of these preferences. The planned use and the actual use of selected beaches in the two parks are examined, and the degree to which the management policies reflect the different physical factors and social preferences of each area is discussed.

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PROJECTING RECREATIONAL USE: A REGIONAL TRENDS APPROACH

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Recreation planning, in order to be cost-effective and responsive to the public's needs, should be based in part on anticipated demand for facilities and activities. Visitor use data currently gathered by the units of the National Park Service are often not in a form useable to the planner for demand analysis. A systematic approach has been developed which allows the planner to assess the actual use occurring at a given area, and to project the likely future demands for such uses and activities, based on evaluation of regional trends from several sources.

Accurate assessment of present and future visitor use requires a reasonable base figure, adjusted to compensate for any bias or inaccurate methods which may be injected into the area visitor counts. The breakdown between intra-regional and extra-regional visitation must also be made for the activities of concern. Several indirect and direct methods are useful for obtaining estimates of this breakdown.

Once the base data has been adjusted and the intra/extra-regional breakdown estimated, projections of likely future use can be attempted. By utilizing such sources as state and region population projections, SCORP per capita demand curves, on-going counts within the park area, and federal and state highway data, a reasonable projection of recreation demand based on regional trends can be developed.

It should be emphasized that familiarity with the park area and the region is a prerequisite for developing reasonable assumptions for use in projecting visitation levels. The effects of a severe gasoline shortage are not considered, as no realistic method for projecting its impact is known at this time.

Further refinements of the regional trends approach which would prove useful are: 1) a method to evaluate the actual changes in demand on a specific area which would likely occur with variation in the level of facilities development, and 2) integration of the trends at a particular area into a multi-state pool to assess the relative demands placed on areas and their facilities in comparison to each other.

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TOURISM IN NATIONAL PARKS -- CYCLES OF MYTH AND BEHAVIOR

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Tourism is a paradoxical human activity, a supposedly "smokeless industry" that produces littered beaches, a cornucopia to local economies that gives rise to inflation and embittered natives; a profitable enterprise that often requires governmental subsidies. Perhaps nowhere is the paradox so striking as in the National Parks. Many of the parks are major world-wide tourist attractions. At the same time they function as unique national preserves. The current influx of foreign visitors to American parks only accentuates the parks' historic role as attractions.

Using the National Parks as examples, this paper is an attempt to clarify some of tourism's paradoxes. We suggest that 1) several cycles of myth and behavior can be observed, 2) these cycles have not yet been systematically examined, and 3) their relevance to resource management is considerable.

The paper is divided into five sections. The first is an attempt to define our special use of the word myth. Far from being ephemeral, we argue that myths are "high social realisms": they explain the incongruities of life and guide our behavior.

The next section is a review of literature. Several social scientists, from varying disciplines and for varying purposes, have examined the role of myth in tourism. These studies support the idea that predictable cycles of myth may be operating.

The third section proposes that four kinds of cycles are of crucial importance: a rise and decline in commercialization; an evolution in the nature of tourist participation; a cycle of sacralization, where places, things and events come to bear symbolic value; and on the ongoing changes of fashion that keep the tourism industry dynamic. These cycles are presented as hypotheses and supportive evidence is drawn from the National Parks.

The fourth section examines the possibility that these cycles of myth and behavior are interrelated, and that many of tourism's paradoxes may be unravelled by a systematic analysis of how commercialization, participation, sacralization and fashion change together over time.

The paper concludes with a discussion of how management of National Parks can benefit from understanding these cycles.

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SACRED SANDS: The Civil Religion of the Indiana Dunes

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Recent studies in the fields of sociology of religion, American religious history, and comparative religion establish the usefulness of the concept of "civil religion" for understanding the transcendent meanings with which Americans endow their political institutions. Research which applies this concept to the National Park system may help explain (1) the peculiar expectations citizens bring to national parks, (2) how interpretations of particular landscapes by the natural sciences are mythically appropriated in the popular mind, and (3) how the parks function in the larger culture as symbolic vehicles for changing perceptions of the proper relation of humanity and nature.

The Indiana Dunes National Lakeshore, the most urban park in the nation, was established in 1966 after one of the longest and most costly conservation battles in American history. The struggle, begun in 1900, was led by artists, social reformers and scientists, including Jens Jensen, Carl Sandburg, Stephen Mather, Jane Addams, and Henry Cowles --one of the founders of the science of ecology. A second generation, led by Illinois Senator Paul Douglas, followed after World War II.

The thesis of this study is that the dunes struggle was motivated by a new form of American civil religion. The dunes advocates perceived the dunes as sacred space--the "centre" of a sacred history which embraced yet transcended the history of the nation, and which extended from the origins of the cosmos to the fulfillment of evolution on earth. The symbolic key to the new religion was the extension of the ideal of social democracy to include the native landscape as well as urban society. This meant the establishment of an equal partnership--a new covenant--between humanity and nature. In consequence, the struggle for democracy and against feudalism in the city was one with the struggle to save the democracy of nature. By "saving the dunes" the conservationists were preserving the "cosmic mountain" on which the transcendent meaning of the new American struggle for social democracy was revealed to them.

The identification of the specific symbols and mythic structures of the civil religion of the Indiana Dunes has implications for (1) the resolution of specific management issues currently affecting the Lakeshore, (2) understanding cultural components involved in early conceptualizations of ecology, (3) envisaging how the presumed conflict of "civilization versus nature," what Perry Miller calls "the American theme," may by imaginatively resolved in terms of dominant symbols of American society.

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NONTRADITIONAL USES OF NATIONAL PARKS

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While National Parks have historically not been considered places for general recreation, they are increasingly attracting visitors with diverse and sometimes unusual expectations, often referred to as non-traditional activities. The appropriateness of any activity in a park setting should be dependent upon legislative and/or administrative directives concerning park purposes. However, these are often very general, suggesting appropriateness may be based upon social definitions of parks as recreation places. The purposes of this study were 1) identify which recreation activities were seen as inappropriate to National Parks, 2) identify reasons for inappropriateness, 3) relate these reasons to perceptions of the meaning of National Parks.

Two hundred eleven visitors to seven Park Service areas in Utah were asked to rate the appropriateness of twenty-two activities (ranging from hiking and picnicking to hang-gliding and trail-biking) in National Parks. Reasons for ratings, respondent participation in the activiites, and definitions of the meaning and purpose of National Parks were also acquired. Seven activities were ranked as most inappropriate: trail-biking, snowmobiling, water skiing, nude bathing, power boating, four-wheeling and hang gliding. None were rejected by a majority of respondents, however.

Definitions of park meaning tended to be general, and did not show any relation to appropriateness ratings. Further, the desired park experience of the respondent also did not influence appropriateness ratings. Personal participation in an activity appeared to be the most influential factor in such decisions. There was also a tendency for persons emphasizing preservation in parks to focus on visitor conflicts as reasons for rejecting activities, while those favoring use of parks were more concerned with environmental impacts. Park visitors appear to have only generalized conceptions of National Parks as places, and make decisions on activities based on personal knowledge or assumed images of the activities.

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Information Systems and Visitor Monitoring Programs

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MEANINGS OF ANIMALS AMONG BACKCOUNTRY HIKERS IN ALASKA

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The fauna in National Park Service areas are considered an important resource, ecologically speaking. Much care and thought is given to the well-being of these species as an integral part of the ecosystem. One factor often considered as having an impact upon animal well-being is the presence of humans. Backcountry hiking brings humans directly into the living habitats of many species. Indeed the direct observation of wildlife is the principal reason many persons take backcountry trips. This paper examines several dimensions of the meanings of animals among samples of overnight backcountry hikers in the McKinley, Katmai and Glacier Bay National Park Service areas in Alaska. This is but one part of a major study of backcountry use conducted during the summer of 1978 by the Sociological Studies Program of the Cooperative Park Studies Unit at the University of Washington. Relationships among animal sightings and expectations, previous sightings, prior animal-related experiences and composite beliefs about animals in general are considered in this paper.

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AGGRESSION IN HUMAN-BEAR INTERACTIONS: THE INFLUENCE OF SETTING

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An ethological investigation of interactions between panhandler black bears (Ursus americanus)and park visitors was conducted in the Great Smoky Mountains National Park from 1976 through 1978. One facet of the study was to ascertain the effects of the setting within which these encounters occurred upon the likelihood of occurrence of ursid aggression. There were 301 panhandling sessions on 33 different bears. Setting variables recorded were: date, time of day, duration of the session, maximum distance from cover, temperature, weather conditions, number of visitors, number of feeding incidents, and sex and age of the individual bear. Seven types of ursid aggression were recorded and each was assigned a numeric value (1 through 7) based upon a ranking of its apparent severity; these were summed to obtain the level of aggression for each session. A multiple regression analysis was performed to determine the degree of relationship between the independent variables (setting factors) and the dependent variable (level of aggression). Results showed that the duration of the panhandling session was the best predictor of aggression; the longer bears interacted with visitors, the more likely they were to become aggressive. The second best predictor was the number of feeding incidents. Two environmental factors - temperature and weather conditions - also affected the likelihood of aggression as did sex and age of the individual bear. These results indicated that there is an inherent approach-avoidance conflict for black bears in panhandling. This conflict was discussed in terms of the naivete of most visitors, the mutual conditioning process, and the factors influencing the threshold of anxiety which led to agonistic behavior.

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BEHAVIOR OF GRIZZLY BEARS IN RELATION TO PEOPLE IN GLACIER NATIONAL PARK

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Studies of human/grizzly bear (*Ursus arctos*) interactions in national parks have generally centered on the bear's aggressive behavior and on the bear's habituation to feeding by people or in the proximity of people. Confrontations have primarily involved (1) the unexpected close-range encounter of a female with cubs by hikers on a backcountry trail, and (2) the aggressive foraging in a campground by a grizzly that has learned to associate human presence with food availability. Between 1968 and 1972, following a concerted effort to make human food unavailable to grizzly bears in Glacier National Park, the rate of grizzly/human confrontations declined. Beginning in 1973, however, the number of encounters in the park began to increase dramatically. An unprecedented proportion of the encounters involved single adults and subadults rather than family groups, and it became relatively common for a grizzly to ignore or approach park visitors, generally on the most heavily used trails.

It is hypothesized that the mechanism leading to these confrontations is similar to the process that takes place when grizzlies aggregate at a source of plentiful food. When bears first arrive, interactions are generally limited to avoidance and flight. With frequent contact, however, each bear must resist or adapt. Prolonged resistance eventually leads to withdrawal from the habitat or to death of the bear; the bears that remain in the area are those that can adapt to the proximity of other bears. In the same manner, increased frequency of human contact coincides with habituation to people by an increasing proportion of the grizzly bears in an area. One result of habituation by a bear is a reduction in its flight distance, which greatly enhances the likelihood of confrontations and human injury.

This paper describes the methods currently being used to test this hypothesis. Records on grizzly bear observations during 1967-1979 are being examined—using coded location, behavior, and bear descriptions—to evaluate differences and trends in behavior, comparing frontcountry and backcountry areas and comparing different age/sex classes of bears. To evaluate the behavior of a human-influenced grizzly bear population, grizzly/human interactions and grizzly bear habitat selection in the vicinity of trails are being examined in an area of high-quality grizzly habitat that receives heavy visitor use.

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DISPLACEMENT OF USERS WITHIN A RIVER SYSTEM: SOCIAL AND ENVIRONMENTAL TRADE-OFFS

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Surveys during summers of 1977 and 1978 on the Lower St. Croix River and the Upper Mississippi River examined the hypothesis promoted by Shelby, Heberlein and others that no inverse relationship exists between actual user density, crowding and satisfaction. Similar to the preceding studies, when each of the study rivers were viewed as individual segments, no relationship between density, crowding and satisfaction was found. However, when viewed as a system, it was discovered that a proportion of users from the Lower St. Croix River who were sensitive to its high use levels were now on the Mississippi. Also, the aggregate user population on the Mississippi were more sensitive to user density than the aggregate Lower St. Croix population. What appeared to be in process was a displacement of users between rivers within a system. Those users seeking high interaction were more inclined to gravitate toward the Lower St. Croix while those seeking low density experiences had a higher than expected proportion on the Mississippi River. Those Upper Mississippi users who formerly used the Lower St. Croix cited crowding (63%) as the dominant reason for their displacement. (Less than .1% of those using the St. Croix who had formerly used the Upper Mississippi cited crowding as a reason for leaving.) As use levels increase, it is likely that this pattern will continue.

It is suggested that a relationship does exist between density, crowding, and satisfaction but that such relationships are difficult to discern with a single site study. Similarly, it is suggested that changes to a resource component which may effect changes in the user population on that site will have effects within the entire resource system by stimulating a displacement of users who perceive negative impacts to the experience they originally sought.

Environmental and aesthetic trade-offs with social components were also examined. When asked to rank a number of rivers they had used for a series of characteristics, those surveyed ranked the Upper Mississippi as the "least crowded" with the best overall recreation experience. The Lower St. Croix was similarly ranked as the "most beautiful" and having the best environmental quality. A shift of users from one river nationally designated "Wild and Scenic" and deemed to have a better resource quality to another deemed to have a better overall recreation experience but poorer resource quality, may indicate that desired experiences are a more driving selection factor than the aesthetic quality of the setting.

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CONFLICT AND DISPLACEMENT AMONG RECREATION ACTIVITY SUBGROUPS

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By categorizing visitors into conventional recreation activity groups, researchers and managers fail to adequately recognize the existence of subgroups within those activities. For this reason conflict and user displacement are most often discussed as an inter-activity confrontation, while intra-activity sources are neglected. Drawing on research examining four-wheel drive vehicle users in Canyonlands National Park, this paper 1) outlines subgroups within the four-wheel drive activity, 2) proposes some general sources of conflict among activity subgroups, 3) explains how subgroup conflicts may lead to user displacement and succession.

Canyonlands National Park, located in southeastern Utah, is a relatively undeveloped, desert park. Use of four-wheel drive vehicles, now confined to designated routes, was a traditional activity for the area even before its designation as a national park.

Once a place visited by only a few committed visitors, better access has increased not only the number of the park's four-wheel drive visitors (spring of 1979 saw a 30% increase in visitation over the previous year), but also their diversity. Results from structured interviews and observations with over 200 spring, 1979 backcountry vehicle users point out that these visitors demonstrate a more diverse set of interactions with the natural environment than the literature or popular stereotypes suggest.

Differences among activity subgroups have received scant attention in the recreation literature. Yet in Canyonlands National Park this may be a potent source of future conflicts. Interviews with the vehicle users were used 1) to formulate general propositions on the sources of intra-activity conflicts that might guide future research and management problem analysis, and 2) to explore the difficulties associated with operationalizing the term "conflict."

Displacement of users (both temporal and spatial) is one result of conflict. However, visitors vary in their willingness to adjust use patterns to avoid conflict interactions. Factors affecting visitors' predisposition to displacement and succession are identified though future research is needed to more rigorously test the relationships.

Insensitivity to activity sub-group differences produces insensitive recreation plans, escalating the tensions among visitors, interest groups and park managers. Any resultant displacement constitutes a qualitative change in the use of the park which may ultimately be at odds with its mandated purpose.

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AN APPLICATION OF GRAVITY MODEL CONCEPTS IN MODELING VISITATION TO THE BACKCOUNTRY OF GRAND TETON NATIONAL PARK

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A great deal of research has been conducted describing visitors to wilderness and primitive recreation areas. Until recently, little research has been concerned with theoretical and quantitative explanations of travel to outdoor recreation sites. The purposes of this paper are to describe a model derived which explains the forces behind travel to the backcountry of Grand Teton National Park and to show the implications which this holds for the projection of use to National Park Service areas.

The gravity model has been employed frequently in transportation research and more recently in the field of recreation research. It operates on the basic logic that the trip interchange between two zones i and j is directly proportional to the number of trips produced in zone i, the number of trips attracted to zone j, and inversely proportional to some function of the spatial separation of the two zones. An application of classical gravity model concepts, the model discussed here, explains use from a given state in the continental United States as a function of the population of the state; its distance from Grand Teton National Park; and variables which describe the natural recreation opportunities in the state and between the state and the park.

Using visitor origin data collected in a comprehensive backcountry use survey (1,663 responses collected in the summers of 1974 and 1975), the model was estimated through multiple regression analysis. It was found that the following variables contribute significantly to Grand Teton backcountry visitation: the population of state i; the distance (in miles) from the center of state i to Grand Teton; the degree of mountainness of state i; the presence of national wilderness areas in state i; and the number of states encountered between state i and the park containing high mountains, national parks, or national wilderness area. The model was easily definable, intuitively correct, and statistically highly significant. It appears that application of this approach can readily be made to other areas of the national park system; and, given reliable visitor origin data over time, can make a valuable addition to techniques currently employed in projecting national park visitation.

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EXPECTED CHANGES IN NATIONAL PARK VISITATIONS: A SPATIAL PERSPECTIVE

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Unlimited travel in the past has spatially diffused National Park visitations with an explainable congestion in popular parks, some of which are far removed from population centers. The advent of inflation, high prices for gasoline and at times a real and perceived gasoline shortage can be expected to alter visitations in national parks.

Past evidence suggests that discretionary leisure/recreational travel by private automobile during an energy curtailment will be altered in terms of duration and distance traveled. Energy conservation can be achieved for leisure/recreation travel by planning trips that are within the limitations of the fuel capacity and mileage range of the automobile. This study describes the opportunity potential for visiting major national parks and national recreation areas assuming that the average automobile has a round-trip range of 350 miles.

The results indicate that the potential visitor impact within a reduced range of travel may have profound significance on visitor satisfaction and on national park management and policy. Alternative planning strategies or scenarios for coping with changes in travel patterns that may evolve as a result of energy reorientation are suggested. Recommendations for measuring and monitoring visitations are included.

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PARK VISITOR RESPONSES TO NATURAL HAZARDS

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This study attempted to identify what factors contribute to national park visitors' perceptions of and preparedness for encountering natural hazards. Increased park visitation has resulted in greater use of backcountry areas, often by persons with little experience in encountering hazards which are present in natural environments. While hazards are a part of such experiences, the probabilities of occurrence may be reduced through the degree of preparedness of participants.

Three major independent variables were hypothesized as being determinants of visitor preparedness: 1) visitor perceptions of whether responsibility for dealing with hazards rests with the individuals or with outside authorities, such as the government or God (this concept is referred to in the hazard literature as "locus of control"), 2) information about hazards provided by the park administration (such as warnings located on signs or brochures), and 3) previous experience. Trip length and knowledge of hazards were also identified as factors which might influence visitor behavior.

The model was tested in four study areas: Arches National Park, Canyonlands National Park, Glen Canyon National Recreation Area, and the High Uintas Primitive Area (to test for differences in non-national park settings). Personal interviews and questionnaires were used to obtain data. Preparedness was measured by developing an index based upon the number of precautions persons had actually taken to mitigate the effects of identified hazards. While results showed that the specific nature of the results varied with the park unit studied, some consistent relationships were noted. Locus of control and Park Service information about hazards had no relationship to preparedness. In contrast, previous experience, trip length, and visitor knowledge about hazards had important influences upon visitor preparations for hazards. As the visitors who face the greatest risks are those with little previous experience and low knowledge of hazards, the results indicate a need for the Park Service to devise more effective strategies of information dissemination than current practices.

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CRIME AND CONFLICT IN URBAN RECREATION AREAS

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The establishment of Gateway East and Golden Gate National Recreation Areas is part of the National Park Service's response to the critical need for high quality urban recreation resources. Recent fuel shortages and inflation have further increased the demand for recreation opportunities close to home. The provision of urban recreation facilities is complicated by pervasive problems of social disorder, ranging from conflicts among park users over nudity or dog-walking to violent criminal acts. While these problems are not peculiar to the urban setting they are particularly acute here. Not only do direct costs of maintenance and enforcement increase but many indirect costs accrue, including decreased recreation opportunity and community support and dissatisfaction of both park users and management personnel. This paper summarizes research in this area, with particular attention to studies in or applicable to National Park Service facilities, and outlines a comprehensive approach to further study.

A review of existing literature on crime and conflict in recreation areas administered by the National Park Service and others reveals that most studies have tended to concentrate on a single problem, such as vandalism or littering, and rural settings. Many interesting hypotheses have been advanced but few have been empirically tested in urban locations. Sociologists, psychologists, planners, and geographers offer applicable theoretical frameworks and parallel research from non-recreation environments. Park Service and other recreation planners, managers and enforcement personnel have developed innovative solutions to problems in their jurisdictions. These researchers and practitioners have provided the basis for a comprehensive investigation of disruptive and destructive behavior in recreation settings. The proposed research approach examines the complex interaction of site characteristics, user behavior, and public, management, and enforcement personnel perceptions. Insights may be gained which would assist not only the National Park Service but all recreation managers and planners in designing programs and facilities that encourage the formation and maintenance of social order.

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AN INTEGRATED FIELD RESEARCH PROGRAM AS PART OF CARRYING CAPACITY STRATEGY FOR OZARK RIVERWAYS

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Carrying capacity has been much discussed as a protection and management strategy for wildland areas, but there have been difficulties in implementing the concept. One of the difficulties has been obtaining measurement of identified components of the concept as they apply to large wildland areas, including river systems. Another difficulty has been in reporting the measurement data in a manner that can be understood and evaluated by concerned individuals in public hearings and other decision-making situations.

Ozark National Scenic Riverways (ONSR) in southern Missouri has met these difficulties through development of an integrated field research program. ONSR encompasses 140 miles of the Current and Jacks Fork rivers. Management concerns center on continuing annual increases of ten to fifteen percent in numbers of canoe floaters, and impacts on the various ecosystems. The 243,000 floater days recorded in 1977 is projected to increase to 515,00 in 1985.

The strategy to develop a field research program to systemically explore the complexities of the river use situation began in 1972. Because the strategy was unique at that time, many decisions had to be made about the scope and nature of the program. Recreational carrying capacity is an integrating concept for considering numbers of people to be accommodated in relation to ecosystem impacts and specific recreational experiences. The state-of-the-art of applications of carrying capability determinations nationally was ascertained. Then the work at ONSR had to go beyond known applications. New field research methods had to be pioneered.

A 139-page report was written in 1978 to communicate the findings of the research program to concerned citizens as well as to managers and other scientists. The report will serve as a major informational input for public hearings to be held in fall 1979. This information should enable capacity decision-making to proceed in a more rational and systematic manner.

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VISITOR IMAGES OF NATIONAL PARKS: THE INFLUENCE OF SOCIAL DEFINITIONS OF PLACES UPON PERCEPTIONS AND BEHAVIOR

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National Parks hold considerable symbolic meaning as expressions of cultural values. This study explores the extent to which visitors to a Park Service area held tangible images of the meaning and purpose of National Parks, the relationship of this image to a person's background, on-site behavior, attitudes concerning the use of such places, and preferences for Park Service management schemes. Two research issues are addressed: 1) the relationship between social definitions of recreation places and behavior, and 2) the feasibility of identifying a primary park clientele for purposes of decision-making. The latter issue has been espoused primarily in regard to wilderness; this study expands the conception, exploring its relationship to parks, and comparing it to wilderness.

Multi-dimensional scales were developed to measure visitors' conceptions of "wildernism" (patterned after Stankey's methodology) and "parkism." Both scales were constructed from 27 Likert-type items, using statements of policy and legal mandates affecting both places. Composite indices distributed respondents along dimensions ranging from high to low correspondence with wilderness or National Park mandates. A sample of 864 recreationists running whitewater rivers in Dinosaur National Monument completed questionnaires containing one of these scales, plus questions concerning park attitudes, perceptions, behavior, and management preferences.

Results indicated that the wilderness scale effectively discriminated among respondents in terms of background, recreation experience expectations, trip characteristics, perceptions of others, and attitudes toward management. In contrast, the "parkism" scale failed to discriminate among respondents in terms of these characteristics. While wilderness is a much more clearly defined concept, the notion of a shared image of parks being a factor in determining on-site behaviors and perceptions is not supported. Further, the development of a primary management clientele based on attitudes linked to legal mandates may be limited.

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RECREATIONAL SATISFACTION AT BUFFALO NATIONAL RIVER

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While recreational satisfaction has been the topic of much discussion and some research, the phenomenon remains relatively poorly understood today. The inability to explain much variance in satisfaction or verify a hypothesized relationship with satisfaction in previous studies has typically been attributed to several possible causes, among which include: (1) the measurement of satisfaction may be unreliable, especially when a single indicator is used; (2) satisfaction is uniformly high, leaving little variance to explain. This study probes the components of satisfaction while controlling for these shortcomings.

River floaters were interviewed at selected access points on the Buffalo National River during summer, 1979. Data obtained included responses to density levels, reasons for participating, a multiple-item overall satisfaction scale, and a discrepancy satisfaction measure for selected reasons for participation. Interviewing was conducted in a variety of environmental and social situations in an attempt to find greater than usual variance in satisfaction.

Findings focus on identifying the components of satisfaction and dissatisfaction. The relationship of the discrepancy measures and other observable variables with the overall satisfaction scale is presented. Methodological and managerial implications are discussed.

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A REMEASUREMENT OF PERCEPTIONS OF CROWDING AS A TOOL FOR RECREATIONAL CARRYING CAPACITY DETERMINATION

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Deciding how much recreation use and what kinds of use can be maintained on large wildland areas has proven very complex, especially as public participation in decision-making has increased. Another paper at this conference (Chilman et al, 1979) has suggested recognizing carrying capacity determination as a process, and systematically acquiring and presenting research information as part of that process.

As recreational use increases, the rate of increase needs to be documented as well as measurements of amounts and types of use. This paper suggests that a remeasurement of visitors' perceptions of crowding can be a useful trend indicator of recreational "quality" to accompany statistics on increases in total recreational use of an area.

Ozark National Scenic Riverways (ONSR) encompasses 140 miles of south Missouri rivers. Canoe float use increased from 143,000 floater days in 1972 to 243,000 in 1977. Canoeists were interviewed to determine their perceptions of crowding in 1972 and in 1977. Numbers of canoeists expressing that more floaters were encountered than desired almost doubled (from 27.4 percent in 1972 to 51.4 percent in 1977), and the numbers of canoeists reporting crowding to be a problem more than doubled (from 14.7 percent in 1972 to 34.3 percent in 1977).

Increased perceptions of crowding occurred on low-density use sections of ONSR as well as high-density. This suggests that redistribution of use from high-density use sections to low-density sections may not be desirable. For public hearings, the remeasurement data appear to indicate that a reduction in the "quality" of river float recreational experiences is occurring in relation to increases in numbers of floaters at ONSR.

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MAINTAINING GEOGRAPHIC SPECIFICITY FOR RIVERWAY USE ASSESSMENT

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Technologies to assess relationships between physical space and the social spatial use patterns are important. During summer of 1977 users of the Lower St. Croix Wild and Scenic River were asked to respond to a map instrument as part of an on-site questionnaire assessing recreational behavior. The users were asked to identify areas traveled, locations of put-in and take-out, and areas along the river they thought were beautiful or avoided (it was a split plot instrument, half the users were asked to react to assessing beauty and half were asked to identify avoidance areas). Over 1000 user-generated polygons were merged using a Wisconsin developed graphing algorithm with hashing routines. This provided plot of beauty curves, area travelled curves, avoidance curves and locations put-in and take-out points.

Data were removed from the map via an eighty-three point grid overlay representing riverway latitudes. "End" values (horizontal grid lines) of each polygon were identified and encoded along with other survey responses. These points afforded calculation of polygon length and location. Polygon sizes ranged from 1 grid point to 83 grid points (distance between adjacent grid points represents .59 miles) with a mean polygon size of 15.9 grid points. However, the mode size was only 7 points or approximately 4.13 miles, with 1 to 7 point polygons representing 35 percent of respondents. Fifty percent of the respondents had polygons of 10 grid points or less, enclosing approximately 5.9 miles or less or one (1) inch on the map provided. Thus it appears that users tried to be highly specific and were in all probability constrained by the instrument rather than by their spatial knowledge of the riverway.

Preliminary analysis indicates that those resource qualities associated to areas with high visual quality are characterized and perceived in a common way across on-site user groups. It also appears that generally the absence of man-made intrusions such as litter and development are common attributes of the areas considered most beautiful.

Beauty and unique environmental areas are the elements of the Lower St. Croix Riverway most often cited as special by users. There is a strong relationship between the portions of the river the on-site visitor uses and the area identified as beautiful.

The Lower St. Croix study exhibits the ability and technologies which exist to understand human use on our natural areas. We can analyze individuals' reactions and qualitative perceptions of the resource, such as beauty, yet we continue to view our resource as a monolithic unit separate from other resource areas with users and use levels something that happens to the area rather than something that happens due to to the area.

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Social Adjustments to National Park Environments:

Implications for Policy

No Abstracts Submitted

OLD FOLKS IN THE NATIONAL PARKS, A SPECIAL POPULATION WITH SPECIAL NEEDS

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This position paper examines the needs of older persons as they relate to use of the national park system. Particular attention will be given to a subset of the older population, those who make camping a major activity amounting to a lifestyle.

Attention will be drawn to the limited but increasing literature which defines this group and its needs. Consideration will be given to the failure of the park system to recognize and plan for those needs. The lifestyle of "full-time" campers will be presented, insofar as it is known, emphasizing its "community" components. Projections for the future of the older campers will be examined, with particular reference to the effects of the scarcity and increasing cost of gasoline.

Suggestions will be made for potentially useful research, divided into proposals designed to produce additional knowledge regarding the composition, needs, and future of the older camper group; proposals aimed at discovering basic social structure formation occurring among them, as a test of sociological theory; and proposals intended to enable the National Park Service to respond to the special needs of this group. Included in the latter category will be comments regarding means by which the reduced financial capacity of the older campers may be accommodated by humanitarian pricing policies and by making part-time work available within the parks.

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A VISUAL QUALITY INVENTORY ALONG A NATIONAL SCENIC TRAIL

PALMER, JAMES F.

Systematic procedures to inventory the physical attributes of our national wildlands and the demographic characteristics of wildland users have long been available to natural resource managers. However, managers have few tools with which they can systematically inventory and assess the visual resources of wildland landscapes. An inventory of visual attributes is particularly useful for its potential to increase our understanding of how users perceive the wildlands for which managers are responsbile.

The first portion of this paper details the procedures used to inventory the visual attributes along nearly 100 miles of the Appalachian Trail. Two methods were used to select trail environments for this visual inventory. First, 184 scenes were randomly sampled throughout the study area. Second, professional judgment was used to select 186 scenes thought to represent important trail qualities. Each scene was permanently recorded using color photography. The location and description of each inventoried scene was recorded in field notes and on U.S. Geological Survey topographic maps. It is estimated that the cost of conducting this inventory and making it available as a management tool is less than $25 per mile.

The paper's second portion explores a few of the ways this visual inventory can be used by wildland managers. Environmental perception research methods are used to classify the inventory into distinct trail types which describe a conceptual taxonomy of the environments encountered by hikers. These trail types are: (1) rural towns, (2) countrysides, (3) vistas, (4) backwoods, (5) trailside features, (6) pathways, and (7) logging activity. The relative frequency of each trail type is calculated from the randomly sampled scenes in the inventory. An assessment of the visual quality of the study area is made, including a discussion of the potential role of each trail type in a hiker's experience. Possible management actions to improve the general hiking experience are discussed based on these findings.

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NATIONAL PARK SERVICE VISIBILITY PERCEPTION STUDY

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Congress, through the Clean Air Act Amendments of 1977, declared as a national goal "the prevention of any future, and the remedying of any existing, impairment of visibility in mandatory Class I Federal areas which impairment results from manmade air pollution." Traditionally, visibility has been defined in terms of distance from an object that is necessary to produce a threshold contrast between that object and some appropriate background. However, visibility is more encompassing than a distance at which vistas disappear. Visibility is the human perception of vista color, texture, and form. The objective of this study then, is twofold: 1) the establishment of a link between human perception and electro-optical physical measures of contrast and color, as a function of vista color, meteorological conditions, and time of day; and 2) a determination of the value that a park visitor places on clean air or an unimpaired view. Visual perception and value thresholds are explored.

Determinations of the functional relationship between perception and physical measurements is established through the use of a visitor survey. Visitors were asked to rate, on a scale of 1 to 10, a series of slides representing various visual air quality levels as a function of meteorological conditions and time of day; 2) determine the level at which they perceive impaired visual air quality; and 3) rate the visual air quality of the same vista as actually viewed on site.

Demographic data such as age, sex, rural or urban residence, educational level, income level, and degree of park visitation are examined as a function of perceived air quality. A human perception scale, relating visual air quality changes to instrumental measurements, it established independent of variance between observers. In addition, the sensitivity of human perception to changes in air quality is examined as a function of vista condition, meteorology, and sun angle.

Since each park is unique in terms of vista characteristics and climatological conditions, methodologies developed in this study and applied Servicewide, can be used to identify those parks with vistas that are most sensitive to air quality impairment.

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PERCEIVED ATTRIBUTES CHARACTERIZING NATIONAL SCENIC TRAIL ENVIRONMENTS

PALMER, JAMES F.

This research is based on the premise that a hiking experience is heavily influenced by what a hiker perceives in the surrounding environment. The purpose of the research is to develop and test a procedure for investigating the qualities that hikers think characterize a National Scenic Trail.

The study area was approximately one hundred miles of the Appalachian Trail through Massachusetts. The scenic, natural and cultural qualities of the trail were photographically inventoried since there was insufficient a priori knowledge about the qualities hikers thought important. The results of a previous study indicate that the average hiker conceptually classifies trail environments into seven distinct trail types: (1) rural towns, (2) countryside, (3) vistas, (4) backwoods, (5) trailside features, (6) pathways, and (7) logging activity.

In the study reported here, sixty-one potential trail users observed slides of fifty-six environments selected to represent a full range of qualities from the trail inventory. These respondents were asked to (1) identify the trail type, and (2) use twenty-four rating scales to describe each of these fifty-six environments.

The contingency coefficient relating these identifications to the prior classification demonstrates that the trail types may be used with high reliability ($C = .819$, $df = 36$, $p < .001$).

An analysis of the scaled responses provides four distinct principal components: (1) experiential quality, (2) cultural pattern, (3) extraordinariness, and (4) topographic qualities. One-way analyses of variance indicate that all twenty-four rating scales and four principal components describe significant ($p < .001$) differences among the seven trail types.

A discriminant analysis provides results comparable to the perceptual identifications. Those scales that are most useful in distinguishing among the trail types describe physical characteristics rather than experiential qualities.

The data and results of this research are used to geographically relate these perceptions to the trail's resource potential. Particular attention is paid in this discussion to the potential role that developed environments can play along a trail.

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COMBINED DOMINANT VISUAL LANDSCAPE TYPES, INDIAN PEAKS, COLORADO. A NEW APPROACH TO CHARACTERIZE THE VISUAL RESOURCE OF OUR ENVIRONMENT

BAUMGARTNER, ROLAND

Most of man's perception is based on sight. Before any question about wise management decisions concerning the visual resources of our environment can be answered, it is necessary to conduct a detailed analysis to determine the integral visual inventory of landscape, as it impresses any involved person. With this method of landscape analysis researchers and planners can specify the potential of any region with an approach suitable for their problem. Knowledge about visual landscape elements is, in addition, a requirement to comprehend their influence on the motivation of any inhabitant or visitor.

The emphasis of this study carried out in the Indian Peaks Area (Front Range, Colorado) is on the combination of abiotic and vegetation features into one map, showing dominant visual landscape types in a scenic mountain area. Second, this research is the indispensable instrument in analyzing different "visual elements" (like single trees, solifluction forms, spectacular viewpoints, etc.) to comprehend their influence on the motivation (expected image, fulfillment) of groups of involved people. Such qualification of landscape elements provides invaluable information for future decisions about landscape development plans.

These landscape studies have resulted in the construction of several Landscape Types Maps for the Indian Peaks Environmental Atlas (IPEA), funded by NASA-PY Grant #NGL--06-003-200.

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ECOSYSTEM STUDIES/INTERDISCIPLINARY APPROACH

ECOSYSTEM STUDIES IN THE HOH RIVER DRAINAGE, OLYMPIC NATIONAL PARK

FRANKLIN, JERRY F.

Interdisciplinary, ecosystem-oriented research is essential to sound understanding of complex, interlinked resource values. The South Fork of the Hoh River on the western slopes of the Olympic Mountains was the site of an intense two-week research "pulse" designed to analyze relationships between geomorphic processes, terrestrial communities, and aquatic systems. This wilderness drainage provided outstanding examples of broad terraces occupied by Sitka spruce-western hemlock rainforests, a major glacial-fed river, and fluvial processes. The research team included 46 scientists and technicians from organizations and ranged from geologists to invertebrate zoologists. Vegetation-landform interactions and their relation to aquatic habitats, structure and function of aquatic ecosystems, fisheries, forest structure, role of logs and other woody debris, and reproductive behavior of tree populations were major topics. The project can be used as a model for other short-term, interdisciplinary efforts and illustrates baseline use of a National Park.

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INTERACTIONS AMONG FLUVIAL PROCESSES, FOREST VEGETATION, AND AQUATIC ECOSYSTEMS, SOUTH FORK HOH RIVER, OLYMPIC NATIONAL PARK, WASHINGTON

SWANSON, FREDERICK J., AND GEORGE W. LIENKAEMPER

Interactions among fluvial processes and forest vegetation create a variety of landforms, plant communities, and aquatic habitats. These interactions are particularly well developed along glacier-fed rivers flowing through forested, glacially carved valleys such as the Hoh River. In the broad Hoh River valley floor, fluvial geomorphic processes create landforms that provide sites for terrestrial and aquatic ecosystem development. Fluvial processes regulate the development of these ecosystems in areas subject to flooding and sedimentation. A series of observations in the Hoh valley illustrate these interactions between physical and biological components of the system.

At least six geomorphic surfaces can be distinguished and mapped on the basis of vegetation and height above river level. Interactions between flooding and forest vegetation vary from one geomorphic surface to another. For example, establishment of some of the vegetation on the four lowest surfaces is correlated with the occurrence of major floods earlier this century. Alder establishment in spruce forests on the fourth geomorphic surface appears to have occurred on seedbed provided by deposits of fire sediment. Alder thickets on lower surfaces in the channel zone of frequent flooding are subject to pruning by bedload movement and floating organic debris at high flows. Large organic debris on gravel bars provides sites where seedlings and saplings are relatively protected from such battering. The alder and large debris work together in these protected sites to create a quiet water environment where fire sediments accumulate and alder stand development can proceed.

Geomorphic processes have created and maintained four aquatic habitats in the valley. The main river channel is characterized by fast, turbid water and shifting channel position. A range of off-channel sites have been cut by the main stream, but provide more quiet water sites that do not carry water all year. Some log jams play important roles in regulating flows into these flood channel sites. Tributary streams crossing terraces have low gradients and quiet, clear water, reflecting a strong influence of local ground water sources in many cases. Valley wall tributary streams are rigorous environments with steep gradients and flashy flows. The influences of forest vegetation on geomorphic form and process increase across this range of channel types from main river to valley wall tributary.

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HABITAT AND FOOD RESOURCES FOR INVERTEBRATE COMMUNITIES IN SOUTH FORK HOH RIVER, OLYMPIC NATIONAL PARK, WASHINGTON

WARD, G. MILTON AND KENNETH W. CUMMINS

Four aquatic habitats in the valley of the South Fork Hoh River were studied for the effects of naturally occurring inorganic sediments (glacial flour) on the structure of stream communities. Availability of food and habitat resources for invertebrates were dependent on the amount of glacial flour present and influence of terrestrial vegetation. The presence of the glacial flour tended to override autotrophic and heterotrophic processes which provided organic detritus and food for the invertebrate community.

The main river channel was most heavily impacted by these sediments as evidenced by the very low algal and invertebrate standing crops, as well as the low proportion of organic matter in the benthos and water column. River off-channel and terrace tributaries represented more stable habitats where less sediment was present and algal and invertebrate standing crops higher.

Increasing amounts of food resources were present as the distance from main channel increased. Largest standing crops of invertebrates occurred in the off-channel and terrace tributary habitats where algae and leaf litter were most available.

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ECOLOGY AND HABITAT REQUIREMENTS OF FISH POPULATIONS IN SOUTH FORK HOH RIVER, OLYMPIC NATIONAL PARK

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Four distinct running water habitats were defined and examined on the South Fork Hoh River -- main river channel, river off-channel areas, terrace tributaries, and valley wall tributaries. Species compositions, densities, and total fish biomasses were distinctly different for each habitat examined.

Habitat formed by the main river channel and its tributaries is controlled by the valley terrace structure and the modifying effects of large woody debris. Large woody debris is important to all habitats examined regardless of size of river. Without large wood, spawning and rearing habitat quality would be poorer even in the large main channel.

Despite high suspended sediment loads, spawning gravels in South Fork Hoh River are relatively clean. Approximately one-third of the entire Hoh River spawning of spring and summer chinook spawn in terrace and valley wall tributaries enter the remaining two-thirds in the main channel.

Virtually all rearing of salmonid fish occurs in river off-channel areas and tributaries. The main channel is used mainly for spawning and migration.

Species composition differed in each habitat. The main channel was used by mountain whitefish, dolly vardon, and some juvenile steelhead (in decreasing order of abundance). River off-channel habitat had predominantly steelhead, sculpins, and coho. Terrace tributaries were dominated by sculpins, coho, and cutthroat. The lower end of valley wall tributaries were dominated by juvenile steelhead and upper valley wall tributaries by cutthroat.

Fish densities and biomasses are highest in streams along the valley floor. Alteration of these areas will have greatest impact on fish production.

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STRUCTURE, COMPOSITION, AND REPRODUCTIVE BEHAVIOR OF TERRACE FORESTS, SOUTH FORK HOH RIVER, OLYMPIC NATIONAL PARK

McKEE, ARTHUR[1], GEORGE LA ROI[2], AND JERRY F. FRANKLIN[3]

Terrace forests of Sitka spruce-western hemlock and red alder were described using transects and 4 1-ha permanent sample plots. Reproductive behavior of trees in the mature spruce-hemlock forests received special emphasis and utilized the plots on which all stems and snaps greater than 15 cm diameter at breast height (dbh) and down logs greater than 10 cm diameter were mapped.

Forest composition and structure varied with landform. Lower and upper terrace spruce-hemlock forests were recognized. The upper terraces have denser stands (143 vs. 64 stems > 15 cm dbh) and a greater importance of western hemlock. The understory on the upper terrace are dominated by mossses and forest herbs and ferns while vine maple and grasses characterize the very open stands on the lower terraces.

Tree reproduction occurs primarily on down logs. Less than one percent of the Sitka spruce reproduction and none of the western hemlock occurred on ground humus. The remainder was on logs and root wads. Sitka spruce provided more favorable seedbed than those of western hemlock. Currently the numbers and survival rates (according to height based life tables) of Sitka spruce reproduction are superior to those of western hemlock. There is evidence, however, of an earlier episode during which western hemlock reproduction was favored over that of Sitka spruce.

Forest composition and structure show both similarities and differences with R. W. Fonda's terrace-based model developed in the main Hoh River drainage. Sitka spruce does appear to be a climax species in these terrace forests in contrast to its role in other coastal types. Naturalized Eurasian weeds are confined to the younger and periodically disturbed lower terraces. Elk appear to significantly influence both tree reporduction and overall understory community composition.

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A BIOMASS AND NUTRIENT ANALYSIS OF FALLEN BOLES IN TERRACE FORESTS, OLYMPIC NATIONAL PARK

LAMBERT, ROBIN LEE

A two part study examining the ecosystem role of fallen dead boles was done in conjunction wtih the establishment of two 1 ha permanent reference plots in each of the two forest types along the South Fork of the Hoh River in Olympic National Park. The first part of the study concerned the quantity and spatial distribution of fallen boles in the two forest types. The second part dealt with chemical changes in the wood as the bole decays and the decay rate of the boles. Because both Sitka spruce and western hemlock regenerate in these forests only on decaying wood, an understanding of the biomass and nutrient dynamics of dead boles is essential.

In the first part of the study we mapped every dead bole greater than 10 cm in diameter in each of the four hectares. In order to separate boles in differing states of decay, we developed a five part decay classification system based on wood appearance and firmness. In four 25 x 25 m plots in each hectare, we did a detailed survey of every log. The dimensions of each log were measured and the decay state noted. From these measurements and density measurements we calculated the average surface area covered by boles, number of boles, volume of boles, and biomass of boles on a per hectare basis. Logs occupied 9 percent of the forest floor and accounted for 115 MT/ha of organic matter.

The second part of the study involved a detailed sampling of dead bole material. Representative samples were taken from boles whose age could be determined. Three samples were taken from each log, each sample from a different point. Bole ages ranged from 0 to 140^{+} years since death. The density of each sample was determined as were N, P, Ca, Mg concentrations. A decay rate of .0124 yr^{-1} was found for small Sitka spruce boles. Larger boles (> 60 cm diam) decayed more slowly.

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RELATIONSHIPS WITHIN THE VALLEY FLOOR ECOSYSTEMS IN WESTERN OLYMPIC NATIONAL PARK: A SUMMARY

FRANKLIN, JERRY F.[1], FREDERICK J. SWANSON[1], AND JAMES R. SEDELL[2]

The South Fork of the Hoh River appears to provide archtypal examples of Olympic valley-bottom terrace ecosystems with minimal modification by valley wall processes. Spruce-hemlock forests are very well developed but vary with geomorphic surface and are much more open than is typical of most northwestern forests; Sitka spruce is a climax component. Major aquatic habitats are a result of interactions between geomorphic processes and forest communities. Off-channel and terrace tributaries are exceptionally valuable aquatic environments. The results of this study show the strong linkages between all parts of natural systems and the value of interdisciplinary efforts. It also illustrates how park areas can function as environmental baselines to provide data on the structure, function, and composition of natural ecosystems to compare with adjacent exploited lands.

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HOME RANGE AND HABITAT USE OF NON-MIGRATORY ELK (*Cervus elaphus roosevelti*) IN OLYMPIC NATIONAL PARK, WASHINGTON

JENKINS, KURT J. and STARKEY, EDWARD

Radio-location telemetry was used to investigate the home range and habitat use of eleven cow elk in the Hoh river valley during summer, 1978 and winter, 1979. The research was the first effort to describe the behavior and ecology of an unexploited Roosevelt elk population on native, unaltered habitat in the pacific northwest.

An elliptical home range method was used to delineate home ranges of radio equipped elk. Annual home range areas varied from 830 ha to 1497 ha ($\bar{x}$ = 1112 ha). No seasonal shifts or reductions in home range areas were observed.

Four known groups of elk existed in the Hoh river study area. Collared elk within each group had nearly identical home ranges a and a high coefficient of association. Home ranges of elk from adjacent groups overlapped but no interchange of collared group members was observed.

The distribution and habitat use of radio equipped elk was studied during a winter, early spring and summer season in relation to twelve physiographic habitat units (modified from Fonda, 1974). Disproportional use of the habitat units indicated that cow elk used various habitats selectively. Chi-square tests for independence confirmed that elk use of habitat units varied seasonally. Results from this study were used to generate hypotheses for additional research.

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ENDANGERED AND THREATENED SPECIES

MONITORING OF ENDANGERED AND THREATENED SPECIES IN SOUTH FLORIDA NATIONAL PARKS

BASS, ORON L., JR., GARY PATTERSON AND WILLIAM LOFTUS

The National Park Service is comprised of over 300 units in 49 states containing approximately 31 million acres (excluding Alaska). Much of this area represents the last refuge for the nation's 198 endangered and 39 threatened species. As a federal land management agency, the National Park Service has a legislated responsibility to conserve federally listed endangered and threatened species. National Park Service policy states that "active management programs, where necessary, will be carried out to perpetuate the natural distribution and abundance of threatened or endangered species and the ecosystem on which they depend." This responsibility can only be met when information on population status is sufficient to permit detection of adverse trends and enable the initiation of research or management action in a timely fashion. In the four National Park Service areas of South Florida (Everglades National Park, Biscayne National Monument, Big Cypress National Preserve and Fort Jefferson National Monument), there are eleven endangered and five threatened species. Some of these species, such as the American crocodile and alligator, are currently subjects of intensive research because of known or suspected threats. Studies of the bald eagle and Cape Sable sparrow have recently been completed and in both, it was recommended that monitoring of the populations be continued because of the potential for catastrophic population declines.

To meet our responsibility we have developed and conducted a comprehensive program to provide continuing information on the status of endangered and threatened species in south Florida National Park Service areas by: (1) analyzing existing information and assessing the status of each species; (2) determining those species requiring monitoring; (3) developing or perfecting monitoring techniques; (4) developing and instituting a cyclical monitoring program for each species; (5) making recommendations concerning species in need of immediate action, either in terms of research where the cause for decline is not known, or management where the cause is known and immediate action could reverse the trend; (6) integrate into a monitoring mode species that have been a research priority.

Here we report on the monitoring system developed for southern bald eagle (Haliaeetus leucocephalus leucocephalus), red-cockaded woodpecker (Dendrocopos borealis), Cape Sable sparrow (Ammospiza maritima mirabilis), Florida panther (Felis concolor coryi), Bahama swallowtail butterfly (Papilio andraemon bonhotei), and Schaus swallowtail butterfly (Papilio aristodemus ponceanus).

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South Florida Research Center
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ROSEATE TERN: OUR NEWEST THREATENED SPECIES?

BUCKLEY, P.A. AND FRANCINE G. BUCKLEY

With a highly local but nonetheless worldwide distribution, Roseate Tern has always been very rare in US waters except for two locations: the Florida Keys/Dry Tortugas, and eastern Long Island/Cape Cod. In the former area it has always been an erratic breeder now probably at an historic low. In the latter area it has been declining steadily over the last 30 years. Helicopter censuses on Long Island, N.Y. revealed that between 1974 and 1978 its breeding population dropped from about 1900 to 600 pairs, the number of terneries in which it occurred dropped from 11 to 7, and the species is now virtually restricted to the Block Island Sound/Gardiner's Bay area where it is also unformly declining. Data from Cape Cod indicate a similar decline there. Major responsible factors include rate predation; scarcity and defoliation of their preferred tall-grass and goldenrod habitat; and tidal flooding. It now appears that these declines are secular, and thus Roseate Tern should be formally classified as a US Threatened Species.

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PEREGRINE FALCON RELEASE AND RECOVERY ACTIVITY IN NATIONAL PARKS

BURNHAM, WILLIAM

National parks and monuments in the West contain a significant portion of the remnant peregrine falcon population. Most parks in mountainous areas contain historic nesting sites, even if not presently active. Since 1977 The Peregrine Fund, the Colorado Division of Wildlife, and the National Parks Service have cooperated in release programs in Colorado national parks. Twenty-three peregrines have been released. The parks hold considerable potential for further release efforts and a future for the survival of the peregrine falcon.

The Fort Collins peregrine falcon breeding facility was established in late 1974. During the past five springs, 111 peregrines have been produced. An additional 59 peregrines have been successfully hatched and reared from wild-laid peregrine eggs. Over 130 of the hatched peregrines have been released into the wild. The releases were by direct-fostering, cross-fostering, and hacking. Eighty-eight of the released young have successfully reached independence.

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RARE PLANT MONITORING IN GREAT SMOKY MOUNTAINS NATIONAL PARK

WHITE, PETER

Great Smoky Mountains National Park (GRSM - 200,000 ha) contains ca. 1,250 native vascular plants, of which 10 percent (ca. 120 species) are listed on the Tennessee, North Carolina, or 1975 Smithsonian endangered and threatened lists. A long term monitoring program in GRSM, begun in 1977, includes sampling for habitat characterization and assessment of change in rare plant populations and native plant communities. Sampling schemes and monitoring strategies are discussed in relation to the diverse flora and vegetation of GRSM. Geographical relations and kinds of rarity are reported for the GRSM flora.

Fifty percent of the listed plants are northern plants either disjunct or at their southern limits of distribution. Ten percent are plants rare throughout their range. Twenty percent are Southern Appalachian endemics. Seven percent are limestone plants of a generally midwestern range, here near their eastern limits. Some listed plants are relatively frequent in GRSM while others are known from single populations. Many plants are rare but only of local significance -- they are not on any of the lists but within GRSM are known from only one to several populations.

Formats for reports on rare plants are discussed. Of crucial importance are management guidelines for action if rare plants are found to be declining. At what level of change should action be taken? These issues are discussed with special reference to GRSM.

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THE DECLINE AND EXTINCTION OF A RARE PLANT SPECIES, VIRGINIA MALLOW (SIDA HERMAPHRODITA (L.) RUSBY), ON NATIONAL PARK SERVICE AREAS.

THOMAS, L.K., JR.

Virginia mallow (Sida hermaphrodita (L.) Rusby) is a rare plant species that is distributionally centered around the slopes of the Appalachian Mountains and extends outward from this center into both the Mississippi River and Atlantic Ocean watersheds. The species occurs in parks of the National Capital Region but has declined so much in the past 93 years that only twelve stems now exist. Research is being undertaken to determine why.

The natural distributions on the eastern side of these mountains is confined to the Potomac River and Susquehanna River watersheds. Within about the last 100 years, approximately two-thirds of the Virginia mallow populations have been extirpated in those parts of each of these watersheds that have been examined. At present a plant species cannot be legally declared endangered or threatened in only a part of its range no matter how rare it is, therefore the rest of the eastern distribution and all the western distribution would need investigation for such status to be determined and considered.

In the Potomac River watershed the extirpated populations are all associated with National Park Service areas by either occurring on park land or adjacent to it. Although there are three small populations on park property only the one at Theodore Roosevelt Island, D.C. is on a natural substrate. Since the T.R. Island population is dying out, this necessitates study of nonpark populations for discovery of key ecological factors associated with the decline.

Ecological factors studied in the field on the few small populations discovered include vegetation type, soil texture and soluble soil salts (cations). Tolerance to high soluble salt concentrations (up to 2200 p.p.m.) may be a factor in their competitive survival.

The low germination of about 3% for this large (up to 4 meters tall) perennial herb is apparently supplemented asexually by reproducing from basal buds.

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DISTRIBUTION, STATUS, AND ECOLOGY OF ENDANGERED BATS OF BUFFALO NATIONAL RIVER

HARVEY, MICHAEL J.

Three bat taxa (Myotis sodalis, Indiana bat; M. grisescens, gray bat; Plecotus townsendii ingens, Ozark big-eared bat) considered to be endangered occur in the Buffalo National River area of the Ozark Mountains in northwestern Arkansas. The Indiana bat and the gray bat are currently on the United States list of endangered species; the Ozark big-eared bat has been proposed for inclusion. The largest known Arkansas hibernating colony of the Indiana bat (currently ca. 1500) exists in a cave within the boundaries of Buffalo National River. The cave also serves as a hibernaculum for several additional bat species (including M. grisescens) and is apparently an important swarming cite for several species. Gray bat summer colonies frequent several Buffalo National River caves and the largest known M. grisescens hibernating colony west of the Mississippi River inhabits an Ozark National Forest cave within a mile of the mouth of the river. Only a single specimen of the rare Ozark big-eared bat has been reported from the area thus far, from an abandoned mine. Current research is being conducted to gather more data concerning distribution, status, and ecology of Buffalo National River endangered bats so that these species can be afforded adequate protection.

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NENE REINTRODUCTION, MANAGEMENT, AND RESEARCH IN HAWAIIAN NATIONAL PARKS

BANKO, PAUL C.

The National Park Service (NPS) is attempting to reestablish and perpetuate wild populations of Nene (*Branta sandvicensis*), the endemic and endangered Hawaiian Goose, in Hawaii Volcanoes National Park (HAVO) on Hawaii and Haleakala National Park (HALE) on Maui. The species nearly became extinct 30 years ago, but populations have been temporarily bolstered by releases of hundreds of captive-reared birds into high elevation habitats by Hawaii State Division of Fish and Game (HSDFG) since 1960. NPS has been breeding Nene in captivity at HAVO and HALE since 1972 to further increase the number of birds in the wild and is attempting to mitigate inimical factors, such as predation by mongooses and habitat alteration by feral goats. In HAVO, 10 breeding pens are maintained in widely separated, lowland locations in order to reintroduce Nene into historically important range where HSDFG has not released birds. In HALE, 3 pens are operated at high elevation and are contributing individuals to the wild population. Concurrent with NPS breeding and release programs, research is being conducted into the breeding biology, factors of mortality, habitat utilization, food habits, and population dynamics of Nene in order to guide management efforts.

An examination of 23 wild and 10 pen nests in and adjacent to HAVO during the past 2 years revealed that productivity was very low. At least 28 wild pairs in 1977-8 and 18 pairs in 1978-9 did not nest or nested unsuccessfully. Factors responsible for or contributing to reproductive failures include a drought during the 1977-8 breeding season and extremely heavy rainfall and nest predation during the 1978-9 season. Egg predation or the death of incubating females was responsible for all known wild nest failures in 1978-9, however the incidence of nest predation was low during 1977-8. Predation was not known to be involved in any losses of goslings, although wild and pen gosling mortality was relatively high during 1977-8. The roles of disease and nutrition in gosling mortality are not yet established. Small clutch size, infertility, embryonic death, egg breakage, and hatchling mortality also contributed to low productivity.

The goal to sustain viable populations of wild Nene in HAVO and HALE can be met only with vigorous management efforts to reduce predation and to maintain adequate habitat. Captive breeding and wild release programs, concurrent with population monitoring and research, must be continued for at least the near future.

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HISTORICAL TRENDS IN PASSERINE POPULATIONS IN HAWAII VOLCANOES NATIONAL PARK AND VICINITY

BANKO, PAUL C. AND WINSTON E. BANKO*

The endemic avifauna of the Hawaiian Islands has suffered many extinctions, while populations and ranges of most of the extant taxa have decreased drastically during the past 200 years. The history of bird populations in what is now Hawaii Volcanoes National Park (HAVO) and vicinity is relatively well known since the 1890's. The historical record includes information from museum specimens, unpublished field journals, personal interviews, and published accounts. To assess recent, local population trends, census plots established in the 1940's were resurveyed during 1973. Information on species composition, frequency of occurrence, and relative abundance was collected, but population densities were not determined.

In HAVO and/or vicinity, 14 of 15 originally extant endemic passerine forms, representing 5 families, were known to be surviving until at least the 1890's. Today, 5 of these taxa are extinct, 5 others are in danger of extinction, while the remaining 5 are still relatively common. In addition, 9 species of introduced passerines, representing 6 families, have become established in HAVO.

Resurveys of census plots revealed that the most common endemic species, *Himatione sanguinea* and *Loxops virens*, increased significantly in frequency of occurrence at some sites, but remained at about the same levels as in the 1940's on others. *Phaeornis obscurus* also increased in frequency at 2 locations. *Chasiempis sandwichensis* frequency did not change significantly at any plot except 1, where it decreased. While *Vestiaria coccinea* frequency remained the same or increased at high elevation sites, it declined markedly at 2 mid elevation plots and was unrecorded at lower locations. *Hemignathus wilsoni*, *Loxops maculata*, and *L. coccinea* were not recorded at any plot within HAVO, but are still present outside the Park. Except for *Acridotheres tristis* and *Alauda arvensis*, whose frequencies generally did not change, the frequencies of all other introduced species increased at most plots.

Factors involved in passerine population changes include changes in availability of important foods (especially insects), diseases and vectors, predation by rats, and habitat alteration.

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ENDANGERED BIRDS IN HAWAI'I'S NATIONAL PARKS

CONANT, SHEILA

A survey of the birds of National Parks on Hawai'i and Maui Islands revealed that both parks harbour native birds, but provide limited habitat for endangered species occurring within or near park borders. Reduction or loss of some species has been marked in recent decades. Large expanses of undisturbed rain forest are essential to insure survival of many species. The threat of introduced plants and mammals dictate that management programs to control or eliminate them must have high priority.

Hawaii Volcanoes National Park has dry forests in which some native species occur and where endangered geese and hawks are uncommon. Since the 1950's three endangered forest birds have disappeared from all forests in the park, and another has been seen only rarely. The southeast rain forests of this park could be crucial to the survival, within park boundaries, of the four endangered passerine forest birds. Introduced plants and feral pigs threaten the integrity rain forests.

The scrub and grasslands of Haleakalā National Park are poor in native bird species, although a few captive-raised, released Hawaiian Geese survive there. This park is also the only known breeding site of the endangered Hawaiian race of the Dark-rumped Petrel, which requires protection from predation. However, the rain forests of this park contain small numbers of at least three of Maui's six endangered forest birds, and surveys may reveal the presence of others. Reduction of introduced plants and animals in these nearly pristine rain forests deserves high management priority. If State protection of rain forests northwest of Kīpahulu continues, forest birds may survive. However, the tenuous status of State forest lands renders protection of park forest critical.

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ENDANGERED SPECIES IN HAWAII'S NATIONAL PARKS

SMITH, CLIFFORD W.

The Hawaiian Islands are just over 2000 miles from any substantial land mass. The extreme geographic isolation has been a significant contributory factor in very high rates of species formation. Consequently, most major groups of organisms have a very high percentage of species unique to Hawaii. The diversity within the Hawaiian honeycreepers, vinegar flies and tarweeds are classical examples of the adaptability and potential speciation after isolation from previous restraints.

Species evolve and become extinct at much higher rates in insular environments than in continental situations. Hawaiian species are no exception but since the arrival of western man in the islands in 1778 the rate of extinction has increased dramatically. The increase in extinction rate is generally the result of the introduction of exotic species. Feral herbivores eat the highly palatable, native species which have evolved in the absence of such organisms and are generally defenseless against them. Other organisms, uncontrolled by previous natural restraints, reproduce and swamp native species and ecosystems. In other instances, introduced diseases and pests destroy organisms which have not evolved resistance to them. All these negative impacts have acted singly or together to extirpate species or reduce their populations to dangerously low levels.

Current resource management programs in Hawaii's two major parks, Haleakala and Hawaii Volcanoes, are directed toward controlling the most obvious problems. The highly successful goat control program at Hawaii Volcanoes National Park has resulted in a vigorous revival of native species and ecosystems though exotic species have responded similarly in some areas. In the meantime, research programs are aimed at establishing which endangered species are present in the parks, where and in what numbers. Other programs are evaluating the impact of exotic species on native species and ecosystems so that resource management activity can be directed where it will be most effective. Restoration programs for a few endangered species are in progress while evaluations of other species are determining whether or not they need assistance.

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FACTORS INFLUENCING THE DISTRIBUTION OF AN ENDANGERED FRESHWATER FISH IN STREAMS IN HALEAKALA NATIONAL PARK

FORD, JOHN I.

KINZIE III, ROBERT A.

Lentipes is a monotypic genus of gobiid fish which is endemic to the Hawaiian Islands. Lentipes concolor, originally described from specimens collected from freshwater streams on the Island of Oahu, is now extirpated on that island and is found only in some remote, pristine streams which have escaped modification or dewaterment. L. concolor is listed by the American Fisheries Society as an endangered species, and it is being considered for inclusion in the International Union for the Conservation of Nature (IUCN) Redbook on endangered fishes. Other investigators have recommended that the species be afforded Federal protection under the Endangered Species Act of 1973.

Where populations of L. concolor inhabit larger island streams with mature geomorphological profiles, adults characteristically inhabit the middle and upper reaches of the stream where they may exist sympatrically with another gobiid, Sicydium stimpsoni and an atyid shrimp, Atya bisulcata. Lentipes is diadromous, possesses adaptations to life in torrential currents, and is even able to climb waterfalls using its fused pectoral fins for attachment.

Stream surveys conducted in the 'Ohe'o reach of Palikea Stream within Haleakala National Park, Kipahulu District on the Island of Maui indicated that the longitudinal zonation of the fish species was typical. However, during a subsequent survey of Pua'alu'u Stream, a small, perennial rheocrene also located within the park, we discovered that Lentipes was unusually abundant throughout the stream course, where it dominated the ichthyofauna. An earlier investigator had suggested this pattern of zonation for the species in small, perennial streams with precipitous debouchments. An hypothesis to account for the bimodality of distribution of this species is developed based on modifications of competition and predation pressure modulated through stream morphology and hydrology. This model is expanded to attempt to describe elements in the critical habitat of this species and management guidelines for its protection in the Park are suggested.

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SEA TURTLE NESTING IN NATIONAL PARKS OF THE SOUTHEAST REGION

Shabica, Stephen

A monitoring program has been designed to systematically survey all national park beaches of the Southeast Region to determine where sea turtles nest, when nesting activities take place, and to estimate relative nesting turtle population sizes through time. This program is being carried out in, and is dependent on, close cooperation with resource management personnel at each of the parks, who essentially perform the actual surveys. The monitoring system is passive in nature. Rangers and park personnel, when on routine beach patrol, carry small notebooks which contain data forms, code descriptors, a key to sea turtles, drawings of the carapace characteristics, and crawl diagrams of the sea turtles. The system is passive in that an active search for nesting turtles, nests, or crawls is not required. While on patrol, if a turtle crawl or nest is observed, the ranger simply fills out the survey form with the pertinent observations. Four species of sea turtles, all of which are threatened or endangered, are known to nest on the beaches in national parks of the Southeast Region. Loggerhead (Caretta caretta), green (Chelonia mydas), hawksbill (Eretmochelys imbricata), and leatherback (Dermochelys coriacea) nests have been observed in 9 of the 17 parks, seashores, or national monuments. Loggerhead nesting ranges from one, in Gulf Islands National Seashore, Florida, to 1,644 in Everglades National Park. A total of 50 hawksbill and green turtle nests were observed on Buck Island Reef National Monument in 1978. Although unrecorded, leatherback turtles are observed nesting on St. John Island, Virgin Islands National Park and in the waters of Gulf Islands National Seashore. Cape Hatteras National Seashore and Cape Lookout National Seashore recorded 19 and 28 loggerhead nests, respectively, in 1978, and probably represent the northern nesting limit for this species. Predation on nests is by raccoons, humans, ghost crabs, and mongoose. The results for the program, which began in 1977, are discussed for the 1978 and 1979 field seasons.

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MANAGEMENT STUDIES OF ENDANGERED AND THREATENED PLANTS

PITTILLO, J. DAN

Endangered and threatened plants usually have exacting habitat requirements and low reproduction. Many of these species are endemics and often have no counterparts (closely related species or varieties) which can be used to make comparative studies. A systematic study of these plants to assist in the development of sound management procedures is warranted. This approach can entail asking a series of questions, such as: "What is the taxonomic status? What type of distribution is known? Is the species difficult to observe in nature? What types of habitats support populations? Is the species a new one and expanding or old and contracting?" Subsequent questions increasingly demand field investigation. The first and most important of these is: "Can the species populations be studied without further endangering them?" If it is judged that studies will not further endanger the species, then questions concerning the weak link in the life cycle become useful: "Are reproduction, dispersion, establishment, and maintenance occurring regularly?" Questions relating to these phases can be organized so that each question becomes more penetrating in any given phase. Once the general basis for a species' low reproduction is established, then alternative procedures to encourage expansion of the population will be made available to the manager.

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PRESERVATION AND CHANGE - DILEMMAS OF RARE PLANT MANAGEMENT IN PRESERVE SYSTEMS

BRATTON, SUSAN
WHITE, PETER

Conservation of rare species is often thought of primarily as a battle to protect the lands on which they occur. Great Smoky Mountains National Park, for example, was originally protected for its landscape and old growth forest as well as for its botanical diversity. Although it has been a legislated preserve for over 40 years and supports over 100 plants of state or national concern, human interference still threatens rare plant populations. Direct impacts include construction of roads and other developments, campsites and trails, legal and illegal collecting, and trampling by visitors. Indirect anthropogenic impacts include air pollution, introduction of exotic species, and disruption of ecosystem structure, especially in the case of overgrazing by ungulate populations. Changes in developed areas both inside and outside the preserve may influence plant populations through modifications in drainage, substrate stability, or herbivore utilization. Important issues for the preserve manager include: At what genetic level should one manage? Should management be ecosystem/process oriented or species oriented? Is "natural" extinction permissible? How should natural disturbances like fire be managed in relation to rare species? Should aesthetically appealing or historic plant communities be maintained?

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MANAGEMENT OF ENDANGERED SPECIES - THE FOREST SERVICE PROGRAM

McILWAIN, JERRY P.

The Forest Service has a positive program designed to contribute to the recovery of threatened and endangered plants and animals, and maintain sufficient populations of sensitive species to prevent the need for their being listed. There are over 70 federally listed species occurring on the National Forest System, and all listed species occurring on forest and rangelands, regardless of ownership, must be considered in Forest Service cooperative programs. Sensitive species include those that have been proposed for Federal classification, are officially listed by a State, or are recognized by Regional Foresters to need special management in order to prevent the need for their placement on Federal or State lists.

Elements of the National Forest program include population and habitat inventory, determination of essential habitat, biological evaluation of all programs and activities for endangered species effects, management planning, formal consultation with the Fish and Wildlife Service, resource management coordination, and direct habitat improvements. These elements are carried out in cooperation with the State wildlife agencies and the Fish and Wildlife Service.

Research is underway with 20 threatened or endangered animals at 10 work unit locations. This research is concerned with species occurring in forest and range ecosystems regardless of landownership.

The Forest Service is establishing programs to aid the State Foresters and private forestry interests with technical training and special assistance.

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ENDANGERED SPECIES AND THE NATIONAL HERITAGE PROGRAM -- HCRS

MERIKANGAS, JACQUELINE B.

The National Heritage Program is a Federal initiative to set up a focal point for ecological inventory (one aspect of which is endangered species). The Federal government has never had a focal point for ecological information as it has had for such elements as soils (SCS), hydrology and geology (USGS), meteorology (NOAA). Instead, this kind of information is scattered throughout many agencies of Federal, State, and local governments, and the private sector with little overall coordination, direction, or definition of priorities.

Recognizing this fact, Interior Secretary Cecil D. Andrus established the Heritage Conservation and Recreation Service (HCRS) to oversee formation of a National Heritage Program which would fill this need.. The design developed by HCRS and a task force of hundreds of knowledgeable individuals is reflected in a legislative proposal entitled "The National Heritage Policy Act of 1979". This proposal, which is one of the highest legislative priorities in the Department of the Interior, was strongly supported by President Carter in his August 2, 1979 Environmental Message.

The National Program seeks to set up a centralized and standardized information system in each State for managing ecological information on terrestrial and aquatic communities, animals and plants of special concern, and important habitat and geologic features. The system adopted by HCRS for managing this data was developed by The Nature Conservancy, a private non-profit conservation group. Their methodology, known as the State Natural Heritage Program (SNHP), has been tested and is currently operating in 20 States and the Tennessee Valley Authority, and has received overwhelming support from Federal land managing agencies as well as the Fish and Wildlife Service Office of Endangered Species and a variety of industries. The National Heritage Policy Act requests Federal agencies, within their missions and mandates, to coordinate and contribute to these State programs.

NPS researchers and planners can do so in the following ways: (1) by targeting inventory efforts to faunal and floral species identified as being of special concern by the SNHP; (2) by verifying or utilizing as a starting point the historical records and leads gathered by the SNHP; (3) by utilizing and updating the SNHP lists of natural history "experts" in the States; (4) by filling out the standard forms used by all SNHP's for recording occurrences and localities of species and communities; (5) by consulting and receiving training from SNHP's in what to look for, where and how to look for it, and how to record it.

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WYOMING NATURAL HERITAGE PROGRAM-INVENTORY METHODOLOGY FOR UPDATING, DEFINING AND MAPPING "RARE" SPECIES.

Lichvar, Robert and Mark R. Stromberg

Increased awareness of Wyoming's rare and endangered species led to a contract between The Nature Conservancy and Wyoming's Department of Environmental Quality to implement the Conservancy's Heritage program for Wyoming. The program is staffed by three scientists. A thorough review of appropriate literature, herbaria and zoological museums establishes a working list of "special" species. Data on each collection or observation are briefly summarized. Each collection or verified observation is mapped on 7.5' USGS quad maps. Summaries or abstracts of each occurrence are stored on computer files, as well as in cross-referenced manual files. The entire state is inventoried to allow comparative decisions. The advantage to this is that agencies (ie, NPS) can have access to data beyond their ecologically arbitrary boundaries. The approach of species-specific data storage allows (uniquely) easily up-dated files as information from NPS, BLM, USFWS, USFS, Wyoming Game and Fish and academic institutions is surveyed. Relative "rarity" can be evaluated by requesting output on those species with minimal occurrence numbers.

During the first six months of operation, land managed by the National Park Service was surveyed for special plant species. Several new populations of two special plant species (Agrostis rossiae, Eriogonum brevicaule canum) were found. Approximately 77 speies on land managed by NPS were identified as special. While the larger, better-studied rare animals are being studied by a variety of agencies, the Heritage program sponsored inventories for the rare Preble's shrew in Yellowstone. Additional studies of molluscs, insects and amphibians of Wyoming are planned. Cooperation with HCRS in the identification and inventory of ecologically unique areas, as defined by maps of species' occurrences, is underway.

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LAKE MEAD AND DEATH VALLEY RARE PLANT STUDIES

HOLLAND, JAMES S. and DENNIS R. SCHRAMM

The preservation of our rare flora is not guaranteed when lands are withdrawn and managed under a preservation mandate. Historic and existing land uses often continue including minerals related activities in both Lake Mead National Recreation Area (LAME) and Death Valley National Monument (DEVA). There are also visitor related impacts through the construction of roads, water systems, visitor centers and sewage lagoons. Additional taxa are directly impacted through removal for cultivation/ horticultural collection purposes, an increasing trend in the southwest.

Since 1973, approximately seventy-five taxa have been recommended for protective status within these two National Park Service Units. In compliance with legislative mandates and management policy, a procedure for analyzing the overall status of rare plant taxa has been developed. This study process should provide LAME and DEVA park managers with the basic data necessary to make management decisions and recommendations for the protection of these elements. Also, it will provide the background data for preparation of biological assessments required by the Endangered Species Act as amended, as well as expand scientific knowledge of distribution, habitat and ecological requirements of these important resources of the National Park System.

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ENERGETICS ANALYSIS/SYSTEMS MODELING

ENERGETICS ANALYSIS AND PARK PLANNING

John F. Alexander, Jr., Ph.D.

In an era of declining world fossil fuel reserves the need to develop national parks in an energy efficient manner has become apparent. This paper presents a heuristic methodology for the analysis of alternative park development plans. The proposed method, based on energetic system mapping and modeling, is illustrated by a case application to the general management plan for Redwoods National Park. Results of the analysis of alternative plans are presented and problems relating to the design of parks as energy savers are discussed.

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ENERGY ANALYSIS OF ALTERNATIVE PARK TRANSPORTATION PLANS

John Henslick

Transportation alternatives for National Parks require different amounts of fossil fuels. This paper uses energetic systems modeling to analyze transportation alternatives proposed for Redwood National Park. Models are constructed for each proposed alternative showing the inputs of fossil fuels and other energies. Further, an examination is made of how different energies interact and the benefits resulting from each alternative. Several alternatives different from the proposed are included showing how similar results might be achieved at lower energy costs.

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A REGIONAL APPROACH TO NATIONAL PARK PLANNING

Ralph Rognstad, Jr.

Energetic systems modeling is used to examine National Park planning from a regional scale. The identification and mapping of various systems that interact to form the regional system are illustrated by a case study of Redwood National Park. The maps, developed from Landsat imagery, help to define the appropriate regional boundary for analysis. An energy model is constructed showing the external flows and internal interactions of the regional system. The model is used as an example in discussing selection of the best scale of approach for solving various planning problems.

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COMPUTER SIMULATION OF AN ENERGY-BASED ECOLOGIC-ECONOMIC MODEL OF THE REDWOOD NATIONAL PARK REGION

Dennis Swaney

A computer simulation model of the two-county region in northern California which surrounds Redwood National Park has been developed to examine ecologic-economic interactions within the region over time. Exchanges between the environment, the external economy, the park and economic sectors of the region are evaluated in terms of the embodied energy of production. The region, which includes Humboldt and Del Norte Counties, has a particularly strong natural resource based economy which is well-suited to a unit of value (energy) which is not restricted to the economic realm. The DYNAMO model consists of six economic sectors: timber industry, fishery, agriculture, government and services, households, and Redwoods National Park. These sectors interact with each other and are "fed by" inputs of energy from the environment and the external economy, in the latter case in exchange for locally produced goods and services. The model demonstrates the environmental basis of the economic system, the park within the local system, and the essential equivalence between energy and money as a unit of exchange.

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EXOTIC SPECIES

ECOLOGY AND MANAGEMENT OF EUROPEAN WILD BOAR IN GREAT SMOKY MOUNTAINS NATIONAL PARK

SINGER, FRANCIS
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European wild boar (Sus scrofa) invaded Great Smoky Mountains National Park in the late 1940's from introduction sites outside of the Park. From 1959 to 1977 the National Park Service live-trapped and released to the adjacent states or destroyed 1,187 wild boar. In late 1976 a more intensive backcountry reduction program and a research program were initiated. The National Park Service control program did not stem the invasion of the remaining unoccupied quarter of the Park by a handful of wild boar in 1979.

Annual population change was 32+ percent and +6 percent during two successive years when mast was abundant and -35 percent when mast failed. Blood condition parameters and fat reserves were reduced during winter of 1978-79 following the mast failure; sows with piglets were particularly stressed. Wild boar were greatly reduced in the Park in three management units, 1976-79. Dispersal back into these units was primarily by males and to a lesser extent by yearling females. Movements and activity of radio-collared wild boar were positively correlated to trapping success. Wild boar moved least in winter when mast was abundant. Capture success then was 49 - 64 man-hours per wild boar captured. Wild boar movements per hour were two times greater during summer, and only 8.2 man-hours were required per wild boar capture. During winter following a mast failure, wild boar movements increased 5.2 times and again capture success increased (15 man-hours per capture). In 1977, only 60, and in 1978, 42 wild boar were removed from an estimated high elevation population of 700 - 1,000. More effective control techniques are needed before any population reduction can be achieved. Presently, control activities are conducted in special protection areas and on any wild boar invading the remaining unoccupied quarter of the park.

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THE EFFECT OF THE EUROPEAN WILD BOAR (SUS SCROFA) ON WOODY VEGETATION OF GRAY BEECH FOREST IN THE GREAT SMOKY MOUNTAINS

HUFF, MARK H.

The European wild boar (Sus scrofa L.) was introduced into the mountains of North Carolina in 1912 and has since spread into the Great Smoky Mountain National Park. Omnivorous feeding and rooting disturbance by this exotic species is a management problem in the park. The Gray Beech Forest is intensively used by the wild boar. Beech (Fagus grandifolia) communities occupied by wild boar displayed changes in understory-reproductive layer. Beech and blackberry (Rubus canadensis) showed high populations in the reproductive stratum. Vegetative sprouts of beech in disturbed areas were significantly more numerous than reproduction in undisturbed areas. Continual hog rooting may change the age class structure in high-elevation beech forests.

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ROOTING IMPACTS OF THE EUROPEAN WILD BOAR ON THE VEGETATION OF GREAT SMOKY MOUNTAINS NATIONAL PARK DURING A YEAR OF MAST FAILURE

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The European wild boar (Sus scrofa), an exotic species, entered Great Smoky Mountains National Park (GRSM) sometime during the 1940's and became established in the western end of the GRSM by the mid-1950's. During the summers of 1977 and 1978, .1 ha survey vegetation plots were established in four areas of the Great Smoky Mountains, including Abrams Creek, Gregory Ridge, Ledbetter Ridge, and Cades Cove, and information on wild boar rooting impact was obtained. During the fall of 1978 and the winter, spring, and summer of 1979, the plots were resurveyed for wild boar rooting and other indications of wild boar utilization. Data show that although wild boar utilization is widespread throughout the western part of GRSM, only a few of the plant communities represented in the sample were intensively rooted. Wild boar utilization was found in 29 of 40 vegetation plots taken in Cades Cove but only those in wet meadow areas and on flood plains showed soil disturbance of over 20 percent of the total area. Intensive rooting was noted in recently burned areas showing strong herbaceous regeneration and around old homesites. During the winter of 1979 very little oak mast was available and oak forest showed almost no rooting disturbance, although some had been noted in the summers of 1977 and 1978. High elevation northern hardwoods and gray beech stands, however, were intensively utilized during the fall and winter and were rooted again the following spring. Winter food habits and impacts on key root forages are presented.

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A COMPARISON AMONG FERAL PIGS AND EUROPEAN WILD BOAR POPULATIONS

SINGER, FRANCIS

A variety of intergradations between feral domestic pigs (Sus scrofa) and introduced European wild boar (Sus scrofa) presently inhabit three national parks, three national seashores, and three national monuments administered by the Southeast Region of the National Park Service (NPS). This paper integrates information from European wild boar in Great Smoky Mountains National Park (GRSM) and feral pigs on Cumberland Island National Seashore with published information on both types; it draws tentative conclusions concerning movements, home ranges, group dynamics, and reproductive biology in order to better understand wild pig populations on the various NPS units.

In the harsher climates of northern and eastern Europe, wild boar rutted in the late fall and produced young only in early spring; additional August births occurred in milder parts of Germany. In contrast, European wild boar and feral pigs produced piglets in any month in the southeastern United States, although fall births were rare. Fall/winter production was often equal to or greater than spring/summer production, except during winter following a mast failure, when reproduction in GRSM was almost nonexistent. Wild boar usually conceived at 18 - 20 months of age in Eurasia and at an average of 16.8 months in GRSM, while feral pigs regularly conceived at 6 - 12 months. In a "typical" year, 75 - 100+ percent of females of wild boar bred and produced 302 - 537 piglets per 100 females. Average fetuses per female ranged from 4.4 - 5.6 in European wild boar populations, and 5.4 - 5.8 in feral pigs. Females may produce two surviving litters per year in all wild swine populations except for wild boar in harsher ranges of northern Europe and Asia. Wild boar were distinctly migratory in mountainous areas, while feral pigs are apparently never migratory. Published densities of wild boar ranged from 0.3 - 60 wild boar per km^2; the highest numbers occurred in flood plain and lakeshore habitat in Asia, Saupark, Germany, and high elevations in GRSM. Feral pig densities are generally higher, 3.9 - 79 pigs per km^2, but this could be due to their occupation of productive coastal marsh, maritime forest, and rain forest habitats. Group size of feral pigs, $\bar{x}$ = 2.2 - 2.7 per group, is much smaller than European wild boar, $\bar{x}$ = 4 - 6 per group.

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AN OVERVIEW OF THE FERAL PIG PROBLEM IN HAWAII VOLCANOES NATIONAL PARK

Warshauer, Frederick R.

Feral pigs are now widespread on the island of Hawaii, inhabiting nearly every available habitat but the alpine stone deserts, the most barren lava flows and urbanized areas. The population densities vary much from place to place as does the degree of impact on the vegetation. My own survey and damage assessment work indicates that few areas in Hawaii can compare with parts of Hawaii Volcanoes National Park for the numbers of pigs and the degree of forest alteration.

In areas of considerable pig impact, most species of plants are affected and many all but disappear. The structure of the forest is also changed drastically, and several life forms are practically eliminated. The rare and endangered status of numerous Hawaiian plants can be blamed on depredations by feral pigs.

The opened areas in forests provide establishment sites for numerous introduced plants, some of which further contribute to the displacement of native species. Internal transport of seeds by pigs is spreading the invasion of several plants capable of nearly completely replacing native forest.

The adaptability of feral pigs to practically any habitat and to surviving human interference makes them a major management problem over most of Hawaii Volcanoes National Park. Their trememdous fecundity and absence of significant natural mortality has made conventional control efforts ineffectual. Hawaii's national parks are faced with the choice of researching and adopting drastic or unconventional control methods or of accepting large-scale degradation of nearly all their wet and mesic forests.

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CHANGES IN A NATIVE ALPINE GRASSLAND IN HALEAKALA NATIONAL PARK FOLLOWING DISTURBANCE BY FERAL PIGS

JACOBI, JAMES D.

The vast number of non-native species of both plants and animals which have been brought into Hawaii by man, particularly during the last 200 years, has drastically altered the Hawaiian ecosystems which they have invaded. Emphasis is now being placed on studying in detail the effect these species have on the native biota, with the intention of developing the best management strategy for particularly threatened habitats. From 1973 through 1979, a study was conducted to determine to what extent disturbance by feral pigs and subsequent invasion by introduced plant species were having on the long-term stability of a unique native alpine grassland in Haleakala National Park, on the island of Maui, Hawaii. In this paper it is suggested that pig rooting has been and continues to be an important factor in allowing for the establishment of several exotic plant species in this area, one of which has the potential for becoming a dominant component of the grassland.

Floristic composition of the grassland, and incidence of pig rooting were sampled along three transects, each approximately 1000 m-long, through the study area. In March 1974, a 10 x 40 m fenced exclosure was constructed, with which changes in the vegetation following removal of the pigs could be monitored. Both plant species composition and abundance were recorded inside and outside the exclosure twice each year from 1974 through 1976, and then annually through 1979.

The results of this study have shown first that the degree of disturbance by feral pigs in this grassland was considerably greater than had been originally imagined by NPS managers. Based on the exclosure study it was found that if steps are taken to totally remove the pigs from this habitat, the native vegetation has the potential to recover to some degree, and at least maintain a stable balance with the exotic species which have already become established. Further actions including removal of some species of exotic plants, plus a limited replanting program with native species which were previously known from this grassland, may be necessary to reestablish this habitat to its more original state.

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VEGETATION IMPACT BY FERAL HOGS,

GULF ISLANDS NATIONAL SEASHORE, MISSISSIPPI

BARON, JILL

Horn Island, Gulf Islands National Seashore, has supported a population of unknown size of feral hogs for more than one hundred years. Research begun in 1977 on the vegetation impacts of these animals was aimed at answering the following questions:

1) Are feral hogs changing the vegetation on Horn Island? and more specifically,
2) Which particular plant species have been detrimentally affected?
3) Is feral hog activity significantly harmful to those plants which function as dune stabilizers?
4) Has hog activity disrupted natural vegetation dynamics?
5) How long do the effects of hog activity last; what is the vegetation recovery rate?

Methods of study included comparison of impacted and unimpacted vegetation sites, comparison of the flora of Horn Island with neighboring, pristine Petit Bois Island, hog stomach content analysis, and hog scat content analysis.

It was concluded that hogs are not changing the vegetation significantly. The most common plant food items include the underground parts of grasses and sedges, particularly Panicum repens and Andropogon spp., slash pine (Pinus elliotii) roots, and the leaves of several more mesic species, including Hydrocotyle bonariensis. Their regeneration is rapid, and complete recovery is achieved within six months for all hog rooted vegetation types except pine savannah. While some dune stabilizers are included in hog diets, such as Uniola paniculata and Ipomoea stolonifera, they are minor food items. Damage to dune vegetation types was insignificant.

The perturbations caused by feral hog disturbance do not disrupt the vegetation dynamics of the island; these exotic animals appear to have a minor effect when compared with the impacts caused by hurricanes, major storms, fire, and drought.

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MOVEMENTS AND HOME RANGES OF FERAL BURROS ON THE TONTO PLATEAU-GRAND CANYON NATIONAL PARK

WALTERS, JIM

From September 1977 to May 1979, the movements of feral burros on the Tonto Plateau have been monitored through sightings of animals fitted with color-coded collars and radio transmitting equipment. Data from six radio collars and 32 color-coded nylon collars has been plotted resulting in a pattern of movements and home ranges for the Tonto Plateau burro herd. These data demonstrate the continual use of major side canyons as year around habitation sites for burros on the Tonto Plateau area. Except for the activity of immature males, there seems to be relatively little lateral movement on the Tonto Plateau by this herd. Sightings of collared animals in the Lower Canyon herd area (River Mile 198 to River Mile 235) also indicate continued occupancy of major side canyons by specific members of the burro herds.

This information has proven useful to resource managers in verifying burro population estimates and in formulating management proposals for these exotic animals.

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EFFECTS OF BURRO FORAGING ON FOUR TYPES OF GRAND CANYON VEGETATION

Bennett, Peter*; Philips, Arthur**; Ruffner, George**; Carothers, Steven**; and Johnson, Roy*

Burros, introduced into the Grand Canyon region 100 years ago, are well adapted to its desert environment. Without known native predators the burros are increasing their numbers by ten to twenty-percent per year. Population control is largely through environmental resistance. They have prospered to the detriment of the natural ecosystems, changing the ecological composition of the National Park.

Research to evaluate this change was undertaken in four vegetation types situated between the canyon rim and the Colorado River. Relative densities, frequencies and cover were determined and the importance value derived. The mean importance value decreased from 0.2126 to 0.1537 with a F-probability for this difference of 0.0359. Data was analyzed to provide the species diversity index (H") and the evenness index (J'). The mean species diversity index declined from 0.1169 to 0.0741 with a F-probability of 0.0008. The degree of decrease varies according to the kind of statistic used, the plant species involved and the complexity of the communities.

Simple communities with fewer than fifteen species are severely impacted. More diverse ecosystems show less effect. The type and degree of effect varies according to the type and complexity of the communities involved. Overall, foraging by feral burros has a demonstrable effect on Grand Canyon ecosystems.

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IMPACTS OF FERAL BURROS UPON THE BREEDING AVIFAUNA AT BANDELIER NATIONAL MONUMENT, NEW MEXICO

WAUER, ROLAND H. and JOHN G. DENNIS

Two breeding bird populations were used as a basis for determining impact of feral burros (Equus asinus) upon a pinyon-juniper woodland environment at Bandelier National Monument, New Mexico. Data were obtained by Emlen transects on two adjoining mesas separated by Frijoles Canyon, a natural barrier to burros. Elevations, slopes, and dominant vegetation are comparable. The non-burro area--Frijoles Mesa--supported a breeding avifauna of 440 individuals, and the burro-used Frijolitos Mesa--supported a breeding avifauna of 303.5 individuals per 40 ha, a thirty-one percent difference. The Frijoles Mesa avifauna provided a significantly higher species diversity value (3.303 to 3.111), higher evenness value (.953 to .924), greater standing crop biomass (15,669 to 8056 grams), and greater consuming biomass (4294.5 to 2192.2 grams). These data illustrate that the Frijolitos Mesa impact area is significantly limited in its ability to support an avian population typical of a non-impacted pinyon-juniper woodlands of northern New Mexico, and that limitation is the result of the deterioration of the environment caused by feral burros.

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THE RELATIONSHIP OF RESEARCH TO RESOLUTION OF A HIGH INTEREST NATURAL RESOURCE ISSUE - MANAGEMENT OF FREE-ROAMING BURROS ON NATURAL PARK SYSTEM LANDS

JOHN G. DENNIS

The free-roaming burro in the southwestern states is an exotic species that is causing measureable impacts to the natural and cultural resources of the region. The free-roaming burro also is the subject of widespread admiration throughout the United States. National Park Service policy requires management of an exotic species whenever such a species threatens the protection or interpretation of natural and cultural resources being preserved in a park area and it is possible to conduct an action that will reduce the impact of the species. The Service's application of this policy to management of burros has generated a number of research programs designed to show the relationship of free-roaming burros to park resources and to identify the comparative values of alternative methods for managing those burros. The results of these research programs have had widely differing impacts on the eventual outcomes of the management planning processes. The causes of these differences are partly related to differences in quality and quantity of the research programs. These causes also are partly related to factors outside the control of any single research or planning program, such as park or Regional Office decision-making based on non-resource factors or central office decision-making based on Servicewide strategy needs. This paper will analyze the burro population and burro impact research programs that have been conducted at Bandelier National Monument, Death Valley National Monument, and Grand Canyon National Park and will show the role that these research programs have played in the development of burro management programs.

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IMPACT OF FERAL UNGULATES ON SHACKLEFORD BANK, CAPE LOOKOUT NATIONAL SEASHORE, NORTH CAROLINA

WOOD, GENE W. and MARK A. MURPHY

Shackleford Bank is a 923 ha barrier island that presently supports 76-107 horses, 68-104 cows, 104-117 sheep, and 73-102 goats. All of these animals are feral; there are no other ungulates on the island. The erection of three 0.04 ha exclosures in each of 4 vegetation types revealed that the feral animals were responsible for reducing net primary production in the first year of measurement as follows: dunes-13%, shrub-herb areas-30%, saltmarsh-52%, and sand flats-4%. No exclosures were erected in the maritime forest vegetation type.

Fecal analyses based on 6 sampling dates throughout the year revealed that horses and cows were the primary feeders in saltmarsh with Spartina alterniflora making up 35 to 70% of their diets throughout the year. Sheep and goats fed primarily on the upland areas. Goats were the primary feeders on foliage of woody plants with this material making up 17 to 82% of their diet throughout the year.

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DAILY AND SEASONAL ACTIVITY PATTERNS OF FERAL PONIES ON ASSATEAGUE ISLAND

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Since 1975 data have been collected on the daily and seasonal activity patterns and movements of the feral ponies that inhabit the Assateague Island National Seashore. This information is necessary for determining home range size, habitat utilization, grazing effects and carrying capacity and is useful in developing management procedures.

During each month data were collected on the behavior of individual ponies as well as on the entire herd using check sheets where various activities were recorded at one minute intervals for each hour of daylight. During the months of June, July, and August, data was also collected during the hours of darkness.

The herds were located either visually or by using radio-telemetry and their locations were plotted on maps of the island. Monitoring of their position over the observation period allowed determination of daily movement patterns.

Grazing behavior occurs at a higher frequency during the winter and is evenly distributed over all hours of the day. In contrast, during the summer grazing is most intense in the early morning and late afternoon. The midday period is spent resting, usually on special resting sites where insect activity is reduced.

A definite movement pattern exists throughout the year. Early morning hours (0200-0600) are usually spent on the beach. The herd then begins to graze on the dunes then moves westward across the island, reaching the saltmarsh by 1000-1400. After several hours of grazing in the saltmarsh, the herds begin to move back across the island toward the beach.

Even though food is of lower quality during the winter, herds move less than they do during the summer. This greater movement may result from the action of biting flies that causes the ponies to take a variety of evasive, anti-insect behaviors.

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EFFECT OF MANAGEMENT ON THE BEHAVIOR OF FERAL ASSATEAGUE ISLAND PONIES

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Assateague Island provides a unique opportunity to study the effects of management on the behavior of feral equines. Animals living on the southern portion of the island, on lands administered by the Chincoteague National Wildlife Refuge, have their natural movements restricted by fencing. In addition, most of the foals produced annually are removed and sold, and adult animals are added or removed from the island, or transferred from one area to another. In contrast, the ponies living on the northern part of the island, within the Assateague Island National Seashore, are not managed to any degree. Their movements about the island are not restricted and their numbers have not been controlled in the past. Since 1975, data have been collected on both groups of ponies.

Because of this variation in the degree of management, a number of differences exist between the southern and northern herds with respect to their behavior. Northern bands display larger home ranges, and a greater amount of daily and seasonal movement. In addition, they utilize a greater variety of habitats than their southern counterparts.

With respect to their social behavior, northern bands tend to be smaller and have different sex and age composition. Most northern bands are composed of one adult male and several family units (an adult mare and one or two of her most recent offspring), while southern bands are made up of one adult male, groups of unrelated adult mares, and few to no yearling or two-year old animals. The northern herd also shows more bachelor bands, composed of young two-four year old males.

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THE MANAGEMENT OF EXOTIC PLANTS

THOMAS, L.K., JR.

The most widespread human impact on park areas is the presence of exotic(nonnative)organisms which have been introduced either advertently or inadvertently. A joint conference of research scientists and resource managers of the National Park Service in 1970 recognized the impact of exotics, both plant and animal, as one of the primary universal problems affecting the National Park System. Some parks and some vegetation types are damaged more than others either because the exotics have only recently been introduced or ecological conditions are different.

The basic principles of exotic control (whether the control of plants or any other organism) center around a knowledge of their ecology and evolution. Such knowledge includes the habitats that exotics are found in, including how they behave in their native habitat. It also includes factors that limit their growth and spread under given circumstances as well as how they are dispersed. In this latter regard, exotic animals are often an important factor in the spread of exotic plants so that an effective exotic plant control program must include control of exotic animals.

There are eight steps in solving exotic species problems beginning with the identification of their presence in the park and ending with a method to eliminate or control them. The actual methods of control are derived from the ecology of the exotic in question. It follows that a knowledge of the life history of the exotic, as well as its ecology, is of paramount importance. The various methods and techniques for control fall under three general stratagies: prevent the introduction and establishment of exotics, change the exotic organism so it is no longer adapted to the present environment, and thirdly, change the environment to effect the same non-adaptation result. Doing nothing may be considered an alternative to each of these control strategies.

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WINTER GROWTH OF JAPANESE HONEYSUCKLE (LONICERA JAPONICA THUNB.) ON THEODORE ROOSEVELT ISLAND, DISTRICT OF COLUMBIA

THOMAS, L.K., JR.

Japanese honeysuckle is an exotic woody vine from east Asia that is overrunning and destroying the forest of this park. A previous study shows that light is a limiting factor in the growth of this species. The report presented here shows that this exotic is a functional evergreen and grows during the winter when most vegetation is dormant.

In an open field, the result of human disturbance of vegetation, soil, and topography, Japanese honeysuckle had invaded and was advancing. The species forms a mat of vegetation which grows over and eliminates grasses and other herbaceous plants. The rate of this advance across the field was measured by placing a series of stakes at the edge of the honeysuckle and periodically measuring the distance from these markers to the new edge of the mat. Between the time of the first frost in the fall of 1978 and the last frost in the spring of 1979, the Japanese honeysuckle made an average advance of 1.7 decimeters. The amount of growth was checked statistically by a paired value t-test and found to be significant.

Some forested areas on the island may receive close to 96% of the sunlight that the open field receives during the winter and the temperature close to the ground in the forest would be expected to have a higher temperature, thus similar growth rates may be expected even in some forested areas.

The evergreen habit, both the morphological one of retaining most of its leaves throughout the year, and the physiological one of active growth throughout the year, give this exotic plant species a competitive advantage over the native vegetation on the island.

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ECOLOGY OF A SUCCESSFUL EXOTIC TREE IN THE EVERGLADES

EWEL, JOHN, DENNIS OJIMA, AND WILLIAM DeBUSK

Schinus terebinthifolius (Anacardiaceae) has successfully colonized thousands of hectares of former farmlands within Everglades National Park. It has several characteristics that make control difficult: it resprouts vigorously; it is shade tolerant; it invades a wide range of sites; it is prolific; and it is widely dispersed by birds and mammals.

Schinus is evergreen, dioecious, has a 50:50 sex ratio, and its reproduction is highly synchronous. Flowering occurs in October, fruits ripen in November, and most seeds are dispersed in December through April. Occasional individuals flower throughout the year, and about 1 per cent are hermaphrodites.

Schinus seedlings can survive years in the dense shade of a parent tree, where they grow very slowly. If the canopy is opened these seedlings grow rapidly. Seedling populations increase dramatically (> 100 per m^2) during late-winter seed drop, but decline markedly as soils dry out in late spring. Seedling mortality increases again as water levels rise in the summer. Some seedlings (ca. 20 per m^2) survive all year in every schinus-dominated forest.

Seed and seedling introduction studies indicate that schinus can germinate, survive, and grow in almost all Everglades ecosystems. Although it is most vigorous in young successional vegetation, its ability to survive in undisturbed ecosystems indicates that it could threaten these if the mature vegetation were disrupted, perhaps by aseasonal wildfire or hurricanes.

Control might be effected by massive elimination of within-park seed sources through bulldozing, followed by herbicide application to kill solitary survivors and new invaders. Alternatively, old schinus-dominated forests might be gradually converted to vegetation dominated by native plants through herbicide-mediated killing of reproductive females. Some inhibition of schinus might be achieved by management practices which favor *Myrica cerifera* (wax myrtle), an ecologically similar native species which is allelopathic to schinus.

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ESTABLISHMENT OF INTRODUCED PLANT SPECIES IN KIPAHULU VALLEY, HALEAKALA NATIONAL PARK

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Kipahulu Valley in Haleakala National Park enjoys the reputation of having one of the best preserved montane rain forests in Hawaii. In 1967, 28 spp. of introduced plants were known to have been present in the upper valley. By 1978, at least 10 more spp. were present, and some of those present in 1967 had increased markedly in range and abundance. In the same period, feral pig activity within Kipahulu Valley increased also. An effort is under way to determine the role of the pigs in the current invasion of introduced plants. Since the Hawaiian Islands have no native terrestrial mammals, the activities of pigs may favor introduced spp. over natives.

The new introductions and currently spreading exotics may be classified into several groups: Accidental temporary colonizers which do not establish themselves, and so are of no immediate interest; grasses and sedges, typically of open, poorly drained habitats; wind-dispersed plants; and those eaten and dispersed by pigs. The distribution and rate of spread of introduced spp. is being studied. An attempt is being made to try to distinguish the influences of feral pigs, rare catastrophic events, accidental colonization, and unaided establishment. Special attention is being given to the case of strawberry guava, *Psidium cattleianum*, which has been especially successful in invading native communities during the past decade.

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HISTORICAL CHANGES IN THE VEGETATION OF ANACAPA ISLAND

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Substantial changes in vegetation cover have occurred on all the Southern California Islands during the last 150 years as a result of browsing and grazing by feral animals. Direct human impact, in the form of farming, construction, and visitation, has contributed to vegetation alterations as well. Evidence of these changes has been acquired by an examination of historical documents and photographs, and, more recently, by the use of permanent line transects.

Existing transect data reveal strong correlations between areas dominated largely by introduced taxa and the intensity of past and present disturbance. A comparative study of populations of Coreopsis gigantea on Santa Barbara and Anacapa Islands was conducted in 1978 and 1979. In the heavily disturbed stands of Coreopsis on Santa Barbara Island 56 percent of the cover was by introduced plants. On East Anacapa Island a Coreopsis population near a current campsite had a 44 percent cover by introduced plants. Stands of Coreopsis on the rarely visited Middle Anacapa Island, on the other hand, were composed primarily of native species with only 9 percent of the cover by introduced weeds.

Of all the Southern California Islands, Anacapa Island presently appears to be dominated by the most pristine vegetation and has perhaps undergone the fastest recovery from previous disturbances. An analysis of both habitat and historical factors is pursued in order to gain insight leading to sound management practices.

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APPROACHES TO THE BIOCONTROL OF CERTAIN EXOTIC TREES USING VASCULAR WILT FUNGI

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Biological control may be a desirable method of selectively eliminating exotic plant species as an alternative to chemical control, which often has objectionable side effects. However, such methods depend on the availability of predatory or pathogenic organisms sufficiently virulent to be effective. A restricted host range within the treatment area, preferably limited to the target plant species, is also necessary.

The mimosa tree (*Albizzia julibrissin*) was selected as an ideal experimental species since it occurs as an exotic in NPS areas and is susceptible to a severe vascular wilt disease caused by the fungus *Fusarium oxysporum* f. sp. *perniciosum*. The pathogen is soil-borne, initially infecting root conductive tissue from which it develops systemically throughout stem and branch tissue. The disease is limited to the genus *Albizzia*.

Inoculation was accomplished by incorporating sand-cornmeal mixtures colonized by the pathogen into the root zone soil, or by direct stem injection of fungal material under various pressure intensities into xylem tissue. Although chemical materials are commonly injected into trees under lower pressures, injection of living organisms under high pressure (300 psi) is unique. Previous attempts at trunk inoculation with this disease by other investigators had been unsuccessful. The present method resulted in extensive distribution of inoculum throughout shoot and root conductive tissue and yielded encouraging results.

The disease was also produced by amending soil of the root zone with the fungus. This method was most effective among dense groups of young trees, but was cumbersome and resulted in greater disturbance to the surrounding environment than did the injection method among larger, individual trees.

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INFLUENCES OF EXOTIC FISHES ON NATIVE ICHTHYOFAUNA OF GRAND CANYON NATIONAL PARK AND VICINITY

JORDAN, JAMES W., CAROTHERS, STEVEN W., MINCKLEY, C. O., USHER, HOWELL D.

Seasonal foraging strategies of common ichthyofauna of Grand Canyon were analyzed to identify potential competition and to quantify occurrences of predation between native and exotic species. Fishes studied included Rhinichthys osculus, Catostomus latipinnis, Pantosteus discobulos, Salmo gairdneri, Salmo trutta, Cyprinus carpio, Ictalurus punctatus. Investigations were also conducted into occurrences of the anchor worm parasite Lernaea cyprinacaea (Copepoda) parasitism on juvenile native fishes, the most probable source of which was introduced exotic species.

Dietary analysis of fishes in Grand Canyon revealed that many food organisms important to one species were also utilized by other fishes. The extent of dietary overlap varied with season and locality. Native species were dietary specialists and generally foraged on or near the substrate. Common exotic species had relatively generalized diets, and varied their activities in response to the availability of ephemeral resources. The potential for competition between native and exotic species was greatest during the winter, a period when foraging activities of most species were concentrated on benthic invertebrates.

Picivorous exotic species of Grand Canyon included S. gairdneri, S. trutta, and I. punctatus, of which only the latter species utilized native fishes in substantial quantities. The greatest incidence of I. punctatus predation occurred at the confluence of the Little Colorado River, an essential nursery area for native fishes.

Although L. cyprinacaea has been identified previously in Grand Canyon, the present investigation appears to be the only instance in which the magnitude of infection has been high. Implications of the infestations are considered serious in that the principal hosts were juvenile Gila cypha, which are currently endangered.

Reductions in the diversity and range of native ichthyofauna of Grand Canyon are primarily attributable to physical modifications of the environment. However, the presence of non-native fishes appears to exert a degree of stress within native populations.

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MANAGEMENT CONSIDERATIONS OF EUROPEAN RABBIT BIOLOGY IN SAN JUAN ISLAND NATIONAL HISTORICAL PARK, WASHINGTON

STEVENS, W. FREDERICK AND A. R. WEISBROD*

This 2 1/2 year study on the European rabbit (Orcytolagus cuniculus) was conducted primarily on the 495 ha American Camp Unit of San Juan Island NHP. The rabbits were introduced in 1880's becoming social, economic, and biologic pests by 1900. This baseline study, conducted 1972-1975 with continuing monthly reconnaisance to the present, identified several factors around which an experimental control program was designed. Important biological factors included: rabbit-induced zootic disclimax within the Park's ecosystem; synchronous production of young in three litters annually with a mean of 7.29 kittens per litter; obligate dependence on warren systems; females were still subject to winter stress during first seasonal estrous; predation on rabbits had minimal effect on numbers; Threatened Species (Bald Eagle) were seasonally dependent on rabbits as prey; climatic factors appeared most important in natural limitation of rabbit population numbers.

An experimental management control program is formulated to improve both methodology and cost effectiveness within NPS philosophy and policy considerations. The program targets 2 alternative goals: (1) 100% eradication of rabbits in a given area and (2) reduction or elimination or rabbit-caused damages. The control program considers various combinations of standard and new techniques applied both simultaneously and serially. Such techniques include mechanical and biological disruption of warren systems, improved isolation fencing, application of approved biocides and chemo-sterilants, and are designed to exploit the rabbit's weaknesses. Disease (i.e. myxamatosis) and predator (e.g. foxes, ferrets) introductions are not considered in this program because elsewhere these techniques are ineffective or have secondary adverse impacts. Ultimate control, especially in island and island-equivalent parks is dependent on 100% elimination. This is simply accomplished on small islands and certain "agricultural islands" on San Juan Island, Washington. On larger islands (greater than 50 ha), more complicated techniques are required, but only after careful empirical analysis.

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STUDIES ON THE ECOLOGICAL IMPACT OF INTRODUCED ROOF RATS UPON NATIVE FLORA IN HAWAII VOLCANOES NATIONAL PARK

BAKER, JAMES K.

The roof rat, *Rattus rattus*, is a non-native rat in Hawaii which was introduced sometime prior to about 1880. It spread rapidly, and it is now a common animal in all the islands from sea level to about 3,000 m elevation. Studies on roof rats in Hawaii have been limited almost exclusively to agricultural damage, and to problems concerning public health. The problems of roof rat impact upon the *native* flora have been little studied.

In recent years roof rats have become especially damaging in Hawaii Volcanoes National Park to the endemic tree *Hibiscadelphus* (Malvaceae), an extremely rare genus in the islands comprising six species, three of which are believed to be extinct. Only eleven mature trees of the type species, *H. giffardianus*, are known to exist. Seven of these trees occur within Hawaii Volcanoes, and four are severely rat damaged. Rat damage has also been severe on a hybrid species, *H. x puakuahiwi*, a cross between *H. giffardianus* and the rare allopatric species *H. hualalaiensis*, transplanted into the park.

Studies on rat damage to *Hibiscadelphus* reveal that roof rats are agile tree climbers, and that they feed upon buds, flowers, nectar, seed pods, and bark. As much as 50 percent of the flowers, and 90 percent of the seed of some trees may be eaten. Major limbs and branches are girdled and killed. It is believed, also, that roof rats eat seed upon the ground, and seedlings, thus preventing the species from reproducing. Only a single seedling of *H. giffardianus* has reached maturity in the last 25 years.

The genus *Hibiscadelphus* produces more nectar per flower than any other native flower so far studied, up to 5 ml per flower in *H. giffardianus*. The copious nectar was once a major though localized source of food for native birds. Roof rats now take much of what nectar is available, and once flowers are fed upon by rats no additional nectar is produced, and the flowers cease to develop so that seeds are not produced.

Roof rats, therefore, are believed to pose serious threats to perpetuation of at least some of the native flora in Hawaii and, perhaps, cause ecological changes in the vegetative composition of native forests.

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INVESTIGATION OF SOME HERBICIDES FOR SALT CEDAR CONTROL

PETERSEN, PHILLIP, CLYDE J. HURST AND JOHN O. EVANS

Salt cedar (Tamarix ramosissima Ledebour), an exotic is widespread in many of the National Parks of the arid western United States. It reproduces prolifically both sexually and vegetatively, and forms almost impenetrable thickets along river and lake shores, and around water holes. As such, it is a considerable hinderance to recreational activities, movement of native fauna, and detracts from natural and historical scenes.

Because of its extent and persistence, eradication or widespread control in the parks is not a goal. We are more concerned with convenient localized control measures to provide recreational access, safety, and protection of water resources for native wildlife, with as little environmental contamination as possible.

This paper will report on the results of studies of methods to accomplish limited control of Tamarix. Study plots have been established at several locations in Utah with varying soil, water and climatic relationships. A broad range of chemicals have been used. These range from the very persistent picloram to the almost nonpersistent glyphosate. We have also been testing some chemicals just released for experimental purposes. Application methods have included foliage sprays on old and young plants and sprouts from cut or burned plants, and cut surface treatments.

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FIRE ECOLOGY

INTERPRETING THE NATURAL ROLE OF FIRE: IMPLICATIONS FOR FIRE MANAGEMENT POLICY

RAUW, DENISON

What role does fire play in our National Parks? How much do visitors know about the ecology of fire? How sensitive is the public to the idea of a natural fire management zone? These are the types of questions confronting many National Parks as fire management policies are being re-examined. At Olympic National Park, knowing how the visitor regards fire and fire management is an important component of this policy-revision process. A cooperative research project between the University of Washington and the National Park Service through the cooperative studies unit on campus, was designed to assess how the visitor and local resident population responds with respect to fire and fire management policy, and to develop an interpretive fire program which discusses the natural role of fire and the rationale behind the revising of fire policies.

The study was conducted in three phases:

I. Assessment of public knowledge and attitudes about forest fire and fire management.
II. Development and showing of an interpretive slide-tape program on the natural role of fire and the changes in fire management policies.
III. Evaluation of the interpretive program in terms of effecting public awareness towards the role of fire and fire management policies.

The results of phase I show that management at Olympic National Park is not faced with a totally adamant public concerning the concept of natural fire management. This finding supports the changing trend in public attitude regarding fire as a natural process instead of an unnatural enemy.

The effect of a fire interpretive slide program in terms of presenting a balanced perspective on the role of fire and the new management alternatives, is discussed in this report.

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FIRE AND RESOURCE MANAGEMENT IN MESA VERDE NATIONAL PARK

OMI, PHILIP N.

This study focuses on the role of fire in the pinyon pine (Pinus edulis Engelm.) and Utah juniper (Juniperus osteosperma (Torr.) Little) forests of Mesa Verde National Park. A data base is being constructed for use in the Park's fire planning process.

Available fire history records and recent meteorological data were examined to establish recent trends during the summer fire season. Results indicate that most fires in Mesa Verde are lightning-caused and small in size. Fuel inventories indicated that the majority of ground fuels are in the larger size classes and would not usually present major fire control problems. However, fuel and weather conditions, e.g. windspeeds, occasionally contribute to rare, but devastating, wildfires in the Park.

A series of simulation exercises was conducted with Park fire experts to assess strategies for coping with the Park's fire problems. Results indicate that modified fire suppression policies may be appropriate in restricted areas of the Park. Larger fires burning with reduced fire intensity may represent a tolerable tradeoff to the rare, yet destructive, fire which is the crux of the Mesa Verde fire management problem.

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ECOLOGICAL IMPLICATIONS FOR NATIONAL PARK FIRE MANAGEMENT: A CASE STUDY OF THE OUZEL FIRE, ROCKY MOUNTAIN NATIONAL PARK

LAVEN, RICHARD D.

As a result of an official review of the Ouzel Fire, approval for allowing natural fires to burn within certain zones of Rocky Mountain National Park has been withdrawn by the National Park Service. One of the primary shortcomings of the natural fire management plan was the inadequate incorporation of ecological information into the plan.

In delineating zones where naturally occurring fire is allowed to burn under specified conditions, consideration should be given to fire history information, the nature and distribution of vegetation types, fuel loadings, elevation, aspect, drainage basin morphology, and local weather patterns.

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THE YOSEMITE AND SEQUOIA-KINGS CANYON PRESCRIBED NATURAL FIRE PROGRAM

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Prescribed natural fire programs have developed along similar lines in Yosemite and in Sequoia and Kings Canyon National Parks, since the three parks have similar topography, vegetative communities, and fire histories. The 325 prescribed natural fires which have occurred in the three parks since 1968 have provided significant insights into the behavior and effects of lightning fires within park ecosystems. The size and distribution of fires have followed predicted patterns and as a result, management units have been expanded to include extensive areas of lodgepole-hemlock and red fir forest.

Prescribed natural fires in Yosemite have burned 3,099 hectares, and 18 out of the 170 fires have been greater than 20 hectares. Seventy-five percent of all prescribed natural fires have been less than .5 hectare, and the average size of a fire is now 18 hectares. As the management units have been expanded, the sizes of fires have increased dramatically. In 1972, there were no fires greater than .5 hectare. From 1973 to 1974, 12% of all fires fell within this range. From 1975 to 1977, 25% were greater than .5 hectare, and in 1978, there were 45% greater than .5 hectare.

Sequoia and Kings Canyon National Parks have had 155 prescribed natural fires which have burned 7892 hectares. Seventy-four percent of these fires have been less than .1 hectare; almost 96% of the total area was burned by fires of 120 hectares or greater, although such fires are only 4.6% of the total. The 1977 Ferguson fire in Kings Canyon National Park burned 4000 hectares over 136 days, the largest prescribed natural fire reported by any agency.

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PRESCRIBED BURNING AND FIRE PLANNING AT LAVA BEDS NATIONAL MONUMENT

MARTIN, ROBERT E.*; OLSON, CRAIG M.*; SLEZNICK, JR., JAMES**

Prescribed burning has been conducted at Lava Beds National Monument to develop prescriptions and techniques which would meet various management objectives. Burning is being conducted to evaluate effects on fuels and vegetation in attempting to return conditions to those existing at the time of the Modoc Indian War of 1873, fought mostly on the area occupied by the monument. Most of the larger burns were also placed strategically as fire management seeks to break up large contiguous areas of heavy fuel loads and reduce potential for catastrophic wildfires. Cost analyses were also conducted.

The first prescribed burns were conducted in cheatgrass in 1974, but 1975 marked the effective beginning of the program. Several parameters were included in prescription development to accomplish various management goals or observe effects. Techniques were developed to establish burn lines without disturbing the soil and to create vegetative mosaics.

Both live and dead fuel consumption on burns was recorded along with many weather, fuel, and vegetative parameters. These data, in connection with burn patterns and vegetative regrowth are being used to develop dynamic fuel models and assess potential wildfire hazard. Burning in nonforested plant communities has reduced fuel loads greatly, which would reduce wildfire intensity. Where grass was plentiful, potential rate of spread often increased the year following fire, even though fire intensity would be reduced. In forested areas, potential fire intensity and rates of spread were greatly reduced for several years.

As part of the prescribed burning research, costs were recorded for all larger burns. Costs ranged up to $20 per acre, depending on size of burn, vegetative type, burning conditions, and management or research objectives.

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RECONSTRUCTING PRESETTLEMENT FORESTS IN NATIONAL PARKS: A NEW APPROACH

Bonnicksen, Thomas M.[1/] and Edward C. Stone[2/]

A half-century old policy of fire exclusion has dramatically changed the forests within many national parks. As a result, the Park Service faces the dual problem of reducing fuels to prevent the occurrence of conflagrations and restoring forest vegetation, and wlidlife, to their presettlement condition. This effort must be firmly grounded on the findings of scientific investigations. There are no second chances available to vegetation managers. The initial restoration program will determine the character of a forest for centuries to come.

The objectives and policies for managing national park forests are clear, the ecological processes operating in these forests are also reasonably well understood, and there are various techniques available for manipulating vegetation to produce desired results. What has not been determined are the conditions to be achieved, the changes which are feasible to make, and the degree to which the ideal state of the vegetation can actually be approximated. All of these questions are addressed by the new approach for reconstructing presettlement forest conditions presented in this analysis.

This approach is based on "aggregation theory" because reconstructing presettlement conditions involves projecting vegetation change. The more heterogeneous the vegetation unit is the less accurate will be the projection. Therefore, vegetation must be classified into homogeneous units, or aggregations, in which change can be accurately projected. Empirical data for illustrating this approach comes from the Redwood Creek watershed in Kings Canyon National Park, California.

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FIRE HISTORY IN THE FOOTHILL ZONE OF SEQUOIA NATIONAL PARK

PARSONS, DAVID J.

The historical occurrence of fire in the low elevation chaparral and oak woodland communities of Sequoia National Park is analyzed as a basis for better understanding fire's role in the evolution and maintenance of these vegetation types. Evidence for both aboriginal and early settler burning in the area is reviewed and, together with the fire suppression policies of the 20th Century, evaluated for their impact on the native plant communities.

Fire records available since the 1920's are summarized by ignition type (lightning or man-caused), time of year, elevation, size and vegetation type. Lightning ignited fires occur most commonly during the late summer and early fall and are more frequent at the higher elevations. They are widely scattered through the foothill zone. Man-caused fires, on the other hand, are more commonly localized along roads and trails and near heavy use areas. They are most apt to be during the peak visitor use months of July and August. A fire history map shows that most of the foothill zone has not burned in at least 56 years and probably not since the late 1800's. This appears to be well below the natural fire frequency for both the chaparral and oak woodland communities. Analysis is also made of the relative size of fires by vegetation type as well as the proportion of each type which has been burned in recent years. The implications of such data for plant succession and future management activities are discussed.

The data presented forms an essential basis for development of a fire management program which involves the use of prescribed burning as a tool to simulate natural fire frequencies and intensities.

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FIRE IN THE FORESTS OF MOUNT RAINIER NATIONAL PARK

HEMSTROM, MILES A.

Over the past 1,000 years, the coniferous forests of Mount Rainier National Park have experienced episodes of catastrophic fire. A recently completed study, involving reconstruction and mapping of large burns up to 750 years old, describes the fire regime in terms of the timing and size of episodes and in relation to climate. Fire episodes in general have been infrequent, widespread holocausts. There is a striking correspondence between major fire events and historically documented or dendroclimatologically reconstructed prolonged droughts. Modern man's impacts on the natural fire regime have been slight but have possibly resulted in increased fire frequency during the late 1800's and decreased fire frequency since then.

Fire frequency was calculated using several common indices. None of these satisfactorily conveyed the picture of fire history shown by the episode reconstruction. The indices were too easily influenced by the size of the region considered, topographic difference, assumptions used to reconstruct fire history, and forest vegetation differences to provide useful comparisons.

Fire frequency and characteristics in relation to forest vegetation types, topography and differing reconstruction assumptions are being further pursued. Results of these investigations will provide guidelines for interpreting fire history studies as well as a more detailed picture of fire in Mount Rainier National Park's forested landscape.

The most important management implications to come from the study so far are: (1) fire has been a very important agent in shaping the Park's forest vegetation mosaic, (2) fire must be included in a management plan to retain natural forest conditions, (3) fires have been infrequent with a return period of over 200 years for major fires, (4) during periods of prolonged drought fires are likely to be holocaustic, (5) modern man's effects on the fire regime have probably been insignificant, and (6) fuel buildups are naturally high and are not the result of fire suppression.

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FIRE AND LOGGING HISTORY OF VOYAGEURS NATIONAL PARK

RAKESTRAW, L., MICHAEL S. COFFMAN and JAMES FERRIS

Voyageurs National Park has had a complex land use history and fire history. The forest was originally exploited beginning in the 1890's, by lumbermen from the United States searching for white pine and by Canadian and American firms in search of pulpwood. Gradually forest practices shifted from an exploitive type of management to that of industrial forestry, with management of the second forest crop and protection of amenity values.

The investigators have used historic records of explorers, surveyors, and lumber companies to check past fires and areas of logging operations. Using the original GLO survey notes, they have constructed a type map of the original vegetation, circa 1880. Their field work has consisted of visiting key areas to study reproduction and forest successional effects of logging and fire.

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FIRE HISTORY AND ECOLOGY OF WESTERN GREAT SMOKY MOUNTAINS NATIONAL PARK

HARMON, MARK

Examination of fire scarred trees from 21 ridges indicates a mean frequency of fire once every 16 years between 1860 and 1940. After 1940, an active fire suppression policy has allowed only two ridges to burn in 38 years. Although forest fuels have accumulated since approximately 1940, most low elevation stands have reached "steady-state" levels. However, further accumulation can be expected in high elevation pine forests and beneath severely disturbed canopies. Frequent man-set fires during the prepark era reduced upland forest fuel biomass between 1/2 to 1/8 the present levels. Tree mortality during fires was found to be a function of species, diameter, and fire severity. For any given diameter and fire severity, thin barked species were found to be twice as susceptible to fire as thick barked pines, oaks, and xeric hardwoods. Increment coring revealed that mesic hardwoods and suppressed pines will survive cool ground fires after 30 - 40 years of growth. A combination of xeric site and frequent man-set fire reduced the importance of thin barked mesic species on upland sites, although complete fire suppression since 1940 has reversed this trend. A combination of fire history, fuels, species growth rates, and age-specific fire mortality indicates upland sites prior to 1940 consisted of very open stands of large, widely spaced trees, with very little tree reproduction.

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FIRE HISTORY OF A RELICT MIXED CONIFER FOREST

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Historically, relatively low intensity ground fires have been common throughout a relict mixed conifer forest in Guadalupe Mountains National Park. Few fire scarred Pseudotsuga menziesii or Pinus ponderosa are present in the forest, but multiple scarred individuals of the thinner barked Pinus strobiformis are common. Comparisons made of the number of trees scarred and not scarred by individual fires in an area also suggest that most fires were of low intensity. However, an analysis of tree size and age class densities indicates that holocausts have occurred in some areas.

Fire dates and fire frequencies were determined by examining cores, wedges, and sections from fire scarred trees. Estimates of the areal extent of fires were made from distribution plots of samples scarred by each burn.

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TWO CENTURIES OF FIRE IN THE HIGH CHISOS, BIG BEND NATIONAL PARK, TEXAS

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Fire occurrences were studied in Pinus cembroides/Muhlenbergia emersleyi woodland and three proximate Cupressus arizonica canyon forest habitats. Dates were determined by tree ring counts from fire scars on Pinus cembroides. Fire frequencies at given sites were also revealed from multiple scars on specimens of Juniperus and Cupressus. I found no difference in the number of fires during the last 200 or so years in these different habitats. Since fires do not always produce fire rings, there were likely many more fire episodes than my sparse sampling (a total of 40 wood sections) revealed, and thus the following are conservative estimates.

On the average a fire took place every 50 years at any given site, but intervals between fires ranged from 9 to 60 or more years. The period 1800-1855 was relatively fire free, but from about 1770 to 1800 fire in Boot Canyon cypress forests and in pinyon savannas on the Rim were as frequent as during more recent years of White Man settlement. Major conflagrations (one or more fires being widespread) occurred about 1903, 1888, and 1871 give or take about 3 years because of false or missing rings on Pinus cembroides.

Episodic ground fire seems an important mortality factor of established pinyon and cypress seedlings and saplings, but as trees grow to larger sizes fire mortality is reduced. The longer fire intervals probably serve as filters that permit trees to survive into larger, fire-impervious sizes. Buildup of ground and understory woody fuels is slow in these low-productivity habitats. Fuel-reduction fires (natural or otherwise) about every 50 years may be an effective way to maintain the pinyon savannas and canyon forests in some semblance of their natural, fire-regulated population structure.

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THE ROLE OF FIRE IN NORTHERN COAST REDWOOD FOREST VEGETATION DYNAMICS

VEIRS, STEPHEN D., JR.

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 analogous to the *Sequoiadendron giganteum*. It has been suggested that the absence of recurrent fire will result eventually in the establishment of a *Tsuga heterophylla* climax. This hypothesis has been examined in research at Redwood National Park. The results have important implications for the long term management of redwood forests as a natural ecosystem.

An intensive investigation of forest history in selected stands in and 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 intensity and frequency is low. *P. menziesii* is a long-lived 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. At higher interior sites *P. menziesii* establishment suggests a fire return frequency of 50-100 years. At more mesic lower elevation sites *P. menziesii* age classes suggest a return frequency of 200-500 years for fires of sufficient intensity to permit the establishment of this species. Fire control in these forests would favor *S. sempervirens* and limit *P. menziesii*.

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FREQUENCY AND SIZE OF FIRES IN RELATION TO ECOSYSTEM VARIABLES IN ZION NATIONAL PARK

WEST, NEIL E.

Fire management planning is aided by knowledge of how frequency and size of fires is related to ecosystem variables. The occurrence of fires in Zion National Park was inventoried by (1) examination of written records, (2) field examination of sites where evidence of fire is obvious, and (3) interpretation of vegetation, soils, fuel loads and direct evidence of fire ("cat-faces", burned snags, charcoal in soil, etc.) at a set of randomly selected sites. The first two lines of evidence gives the impression that fires are more areally important than was indicated by the third method. File records indicate 221 fires have burned about 700 hectares over the past 47 years. Many of the fires obvious from field examination were not recorded. There was a bias toward reporting of fire near the more heavily traveled portions of the park and that which can be seen from the one fire lookout. The written records have generally become better in recent decades. Much of the park doesn't have fires at all because of much bare rock (about 64%). Vegetation and litter is so sparse and patchy at lower elevations and on steeper slopes that most fires cannot spread beyond a fraction of a hectare. Ponderosa pine and oakbrush-manzanita dominated vegetation on level to gently rolling mesa top topography above 2000 m in elevation is the only situation where fires are at all frequent and of large enough size to be of major concern to park managers. These mesa tops attract the majority of lightning strikes in late summer when most fires occur. The effects of fire control on such sites should be studied further.

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CLIMATIC FACTORS INFLUENCING LIGHTNING FIRES IN OLYMPIC NATIONAL PARK

HUFF, MARK H.

Records indicate that large lightning fires are infrequent and occur under unusual weather conditions. Since 1916, over 80 percent of the 7,250 acres burned in Olympic National Park was caused by lightning fires. Fire occurrence may be determined by fuel moisture as a function of various long and short term climatic conditions.

This study examines the significant climatic variables of lightning fires larger than one acre in size. Climatic information of lightning fire years is statistically compared to non-lightning fire years. In addition, relationships between acres burned and climatic variables were examined.

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WATER STRESS AND PHENOLOGY OF FOOTHILL ZONE SHRUBS IN RELATION TO FIRE MANAGEMENT

BAKER, GAIL A., RUNDEL, PHILIP W., AND PARSONS, DAVID J.*

Plants in a Mediterranean environment are subject to seasonal variabilities and intensities of rainfall. This seasonality is reflected in the progression of physiological and phenological characteristics of the plants, beginning with the onset of the rainy season and continuing through the summer drought. The progression of phenological events has been followed in the dominant shrubs and trees in the foothills of Sequoia National Park. Data on plant water stress, phenology and environmental measurements have been taken over a two year period and indicates that seasonal changes in plant water content and growth contribute to the seasonal changes in plant flammability. These data have important implications to fire management techniques in terms of choosing favorable times to do controlled burning and predicting the intesity and behavior of natural fires.

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THE ROLE OF SHRUB STRUCTURE AND CHEMISTRY IN THE FLAMMABILITY OF CHAPARRAL SHRUBS

RUNDEL, PHILIP W., PARSONS, DAVID J.,* AND BAKER, GAIL A.

While fire is a natural aspect of the physical environment of chaparral ecosystems, many characteristics of the vegetation act to promote fire rather than inhibit fire spread. Recent studies of chaparral communities in Sequoia National Park and other areas provide evidence that canopy structural form and foliage chemical characteristics may influence fire frequency and intensity. Canopy structure of plants influence the amount of energy available for combustion and the rate at it which this energy is released. The chemical composition of fuels influence ignitibility and the available energy content. These flammability-related characteristics may have great ecological significance to fire-adapted plants, as well as profound importance in planning fire management policies for chaparral areas.

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THE DISTRIBUTION AND DYNAMICS OF FOREST FUELS IN THE LOW ELEVATION FORESTS OF GREAT SMOKY MOUNTAINS NATIONAL PARK

HARMON, MARK

In fall 1977 a study was initiated to examine forest fuel accumulations after 40 years of fire suppression in Great Smoky Mountains National Park. Variations in fuel biomass, decay rates, and production were examined along gradients of elevation, topography, aspect disturbance, and community structure. Leaf litter production ranged between 350 - 450 grams per meter for mature stands and did not increase significantly in stands with basal areas larger than 10 meter^2 (hectare^{-1}). Major differences between stands in 01 and 02 horizons of the soil were correlated with forest cover, elevation, and time since last fire. Leaf decay rates were found to correlate with elevation and litter quality. Major differences in downed wood biomass were related to major canopy disturbances (e.g., fire, blowdown, insect damage, and chestnut blight), the time since disturbance, and the woody species killed. Hardwood and oak wood were found to decay faster than wood of pine or hemlock. Fires were found to remove 70 - 90 percent 01 and 25 - 90 percent 02, depending upon season and moisture content. Repeated man-set fires on upland sites during the prepark era reduced forest fuels to 1/2 - 1/8 the present levels. At present, most forest floors have reached a "steady-state" value; further fuel accumulation will probably only occur in conifer forests above 3,000 feet and within severely disturbed stands.

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FOREST DYNAMICS AND FUELWOOD SUPPLY OF THE STEHEKIN VALLEY, NORTH CASCADES NATIONAL PARK COMPLEX

LARSON, BRUCE C., and CHADWICK DEARING OLIVER

Sustained fuelwood supplies from National Recreation Area land in the Stehekin Valley (Washington) were estimated during the summer of 1979. The valley residents had been dependent on this source of wood for heating and cooking since before the U.S. National Park Service acquisition of land management responsibility. The accessible forested area of 4,000 acres was stratified for sampling. The forest stand dynamics of each area was assessed. From this information the growth and mortality rates were determined by species. The U.S. National Park Service and valley residents will use this information to determine future fuelwood allotments.

Preliminary aging and other data suggest that the forests existed in either even-aged or several-age-class structures which initiated after fires, windstorms, or floods. More all-aged stands were created by frequent partial cuttings by pioneers and, later, inhabitants. Species composition in each area was a result of soils, types of disturbance, and time intervals between and after disturbance.

Species distribution and vegetation types found before pioneer intervention would have reflected the frequency and types of natural disturbance during the preceding few hundred years. The Park Service and Stehekin residents will have a choice of species to be cut (or dead stems to be salvaged) and silvicultural systems to be used, depending on what vegetation types they wish to foster.

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FIRE AND LANDSCAPE DIVERSITY IN YELLOWSTONE NATIONAL PARK

ROMME, WILLIAM H., AND DENNIS H. KNIGHT

The sequence of vegetation mosaics covering a 74-km^2 subalpine watershed in Yellowstone National Park during the last 200 yrs was reconstructed based on past fire occurrence and forest succession. Indices of landscape diversity were computed for each reconstruction, treating forest types and successional stages as taxa and incorporating components of richness, evenness, and patchiness. Landscape diversity was highest in the early 1800's following very large fires in 1739 and 1795 which together burned more than half of the watershed. No large fires have occurred since 1800, and landscape diversity has gradually decreased due to forest maturation. This decline appears unrelated to human fire suppression, being instead part of a natural 300-400-yr cycle of extensive, destructive fires that periodically interject major landscape change. The landscape reconstructions were repeated using a simulation model and hypothetical fire management policies of total fire exclusion and selective fire control (permitting only small fires to burn). The principal effect of both hypothetical fire regimes was to reduce the magnitude of periodic fluctuations in landscape diversity, resulting in more constant landscape composition over time. This difference may have implications regarding wildlife habitat and other ecological characteristics.

The natural fire cycle in lodgepole pine and spruce-fir forests of Yellowstone National Park results from changes in the fuel complex during succession. Fuels capable of supporting a major fire usually do not develop until stand age 300-400 yrs, and ignitions prior to this time usually extinguish naturally before covering more than 1 ha. Thereafter the occurrence of a destructive fire is probabilistic, depending on the simultaneous occurrence of an ignition source and warm, dry, windy weather. Recent fire control efforts have had little impact on normal landscape dynamics in the 74-km^2 study area because they occurred during a portion of the natural fire cycle when large fires were unlikely anyway. However, a century or more of total fire exclusion could produce significant departures from natural long-term landscape patterns.

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NATURAL FIRE IN THE SIERRA NEVADA, CALIFORNIA

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Pre-burn and post-burn populations of tree and brush species, forest pathogens and birds were compared on two naturally ignited fires at 2100 m elevation in the southern Sierra Nevada of California. Control plots were used for a comparison of soil nutrients, soil moisture, herbaceous cover, and bird use on burned and unburned sites. Significant differences in soil moisture were discovered at 30 cm depth on the one-year and two-year old burns. Nitrogen, phosphorous, calcium, magnesium and soil pH were significantly higher at 10 cm depth on the two burns than on the unburned sites. Differences in bird density and species diversity on burned and unburned plots indicated a possible correspondence with changes in herbaceous density and diversity. While forest pathogens were temporarily reduced, post-burn insect infestation appeared to be proportional to tree damage. Small Pinus jeffreyi and Pinus contorta survived light burning, but a large number of Abies concolor were killed. Arctostaphylos patula reproduction was proportional to both the original density of the brush and to fire intensity. Burning rid brush areas of invading trees. It was concluded that the fires had both short and long term beneficial effects on soil, plant and animal systems.

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IMPACT OF FIRE IN A TROPICAL SUBMONTANE SEASONAL FOREST

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Though natural fires do not appear to have played an active role in the succession of most plant communities in Hawaii, the communities in active volcanic areas have probably adapted to some extent. Prior to 1970, fires in Hawaii Volcanoes National Park were infrequent and small in area but since then they have been more common and extensive. This abrupt change can be correlated with the spread of two species of *Andropogon* into the area and a successful feral goat control program. Recent fires have resulted in significant initial reductions of the native plant communities and a dramatic increase of exotic *Andropogon* and *Bulbostylis*.

A control-burn exercise allowed us to evaluate the impact of fire in a tropical submontane seasonal area vegetated with an open *Metrosideros* forest and an understory of native shrubs and exotic grasses. Most of the native species in the area were killed by the fire. *Metrosideros*, though not normally considered a fire-tolerant species, is regenerating. Approximately 50% of the trees are sprouting from the base of the trunks. However, the growth morphology of the trees determines their fire tolerance. Eighty five percent of the trees with single trunks were killed but only 25% of the trees with two or more trunks less than one foot apart were killed.

The total plant cover in the area prior to the fire was 30%. Within six months of the fire, a moderate regeneration (12% cover) had occurred, all of it by exotic species predominantly *Andropogon*. One year after the fire, though the exotic plant cover was 30%, only one native species, *Railliardia ciliolata* showed some recovery. Two years after the fire, *Andropogon* covered 50% of the area and many seedlings of the endemic *Dodonaea sandwicensis* were present. After four years, the colonization of exotic species has leveled off whereas the native shrubs continue to recolonize the area. It is too early to tell whether or not the native species will regain their former cover and dominance in the area.

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VEGETATIVE SUCCESSION FOLLOWING FIRE IN A SUBALPINE MEADOW OF THE SOUTHERN SIERRA NEVADA: ONE YEAR POST-BURN

DE BENEDETTI, STEVEN H.

A lightning ignited fire entered and spread throughout a subalpine meadow (elevation 2790 m) in Kings Canyon National Park, California during August and September of 1977. Fires of this extent occur infrequently in subalpine meadows of the southern Sierra Nevada. The fire smoldered extensively, resulting in near total combustion of the vegetation and surface organic material, leaving ash 1 to 20 cm deep. Early stages of vegetative succession are reported and contrasted with immediate post-burn conditions in an intensively burned portion of the meadow.

Cover by live herbaceous plants increased from less than 5.8% immediately after the fire to 36.1% one year later. Broadleaf plants were more frequent and had greater cover than did grasslikes. Most colonizers were perennial species established from seed and which were also common to unburned portions of the meadow. Several species not observed in adjacent unburned areas were abundant in the burn. Conversely, several species common to the unburned areas were not observed in the burn. Moss and liveworts, not observed immediately after the the fire, covered an additional 30.7% of the surface one year later. Hence, much of the meadow surface was stabilized within one year after the fire.

The surface was lowered relative to adjacent vegetation where intense fire occurred. While some puddling and initial stages of channelization were observed, no catastrophic change in the character of the meadow is suggested by one year post-burn conditions.

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FUEL DYNAMICS IN TWO NATURAL FIRES IN SEQUOIA-KINGS CANYON NATIONAL PARKS

OMI, PHILIP N.

Forest fuels were inventoried in burned and unburned portions of two fires allowed to burn under the natural fire management policy of Sequoia-Kings Canyon National Parks. Results support the variability of fire behavior and effects in the three plant communities sampled, although generalizations can be made relating specific fire behaviors to the conditions within each community.

The most consistent fuel differences between burned and unburned plots were in the manzanita community type, dominated by Arctostaphylos patula. Unburned-burned differences were least apparent in the pine type (Pinus jeffreyi and P. contorta). Differences between burned and unburned plots of the fir type (Abies concolor) were masked by high sample variability, but indicate as well the wider range of fire impacts expected in this community. Extrapolations from litter, surface, and crown fuel inventories are used in deriving hypothetical fire regimes and management implications for the Sugarloaf Valley study area.

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THE EFFECTS OF PRESCRIBED BURNING ON MULE DEER WINTERING AT LAVA BEDS NATIONAL MONUMENT

Alice Purcell*, Roger Schnoes*‡ Edward Starkey*

Research was initiated at Lava Beds National Monument during the winter of 1976 to determine the effects of a prescribed burning program on the mule deer population wintering within the monument. The objectives of this study were: to determine the distribution and movements of deer on the winter range, especially as related to burned areas; to determine winter food habits of deer and any changes in food habits resulting from burning; and to determine general behavioral responses of deer to the burned areas. Based on the sizes of home ranges, and the size of contiguous burned areas, it was concluded that deer would not be adversely affected by the prescribed burning program.

Visual observation, radio telemetry, and pellet-group plots were utilized to examine deer distribution, seasonal movements, and winter food habits. Individual deer occupied discrete home ranges on the winter range. Deer utilizing areas of tall, dense vegetation occupied smaller home ranges than deer occupying more open shrub habitat. Bitterbrush, Pursia tridentata, was the most important browse species during the winter months. Utilization of green shoots increased, particularly in burned areas, as the winter progressed. Deer increased use of the burned portion of their individual home ranges during the fall and spring.

Migratory deer utilized the same home range from year to year and did not appear to significantly alter their home ranges to utilize newly burned areas adjacent to their home ranges. The particular "subpopulations" of deer whose home ranges overlap burned areas may show increased productivity as a result of the increased availability of grass and forb species within their home ranges.

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EFFECT OF FIRE ON SLASH PINE COMMUNITIES WITHIN EVERGLADES NATIONAL PARK

TAYLOR, DALE L. AND ALAN HERNDON

A management decision has been made to use prescribed fire to maintain the south Florida slash pine (Pinus elliottii var. densa) forests within Everglades National Park. The 20,000 acres of pine forests occur on Miami oolite and differ ecologically from pine forests found on sandy soils to the west and north. There is a high number of endemic plant species, indicating a long evolutionary association with fire. These pine forests are maintained by recurrent ground fire, without which, hardwood understory species would become dominant after 15-25 years of succession. Prescribed fire studies to measure fire effects were started in 1958, and continued to date. These studies show no measurable effect from fire on pine growth rate or basal area change. Tentative conclusions indicate the same herbaceous plant species present before fire are again present in almost equal density and frequency within four months post-fire. Hardwood growth has been held in check by fire.

Differing fire histories in 60 one-tenth acre plots allow tests of fire effect on changes in height and diameter of pines. Average diameter growth rate was .25 cm/yr. Diameter growth rate was not significantly different between areas burned one to four times. Basal area increments averaged .1 m^2/ha/yr and was not significantly different between areas burned one to four times.

Number of hardwood stems in 3-5, 5-10, and over 10 foot height class, height index, and percent of stems in 3-5 foot class were measured in the 60 one-tenth acre plots. Number of stems in the over 10 foot size class has decreased, but total number of stems has remained constant. Species composition in hardwood understory has not changed over the period of record.

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THE EFFECTS OF PRESCRIBED FIRE ON THE VEGETATION OF LAVA BEDS NATIONAL MONUMENT, CALIFORNIA

OLSON, CRAIG M., ROBERT E. MARTIN AND ARLEN H. JOHNSON

The effects of prescribed fire on the grass, shrub, chaparral, and pine communities of the Lava Beds National Monument were monitored from 1975 to 1979. Changes in vegetation structure, composition, and frequency was determined on fifteen prescribed burns conducted under varying weather and environmental conditions.

Bunchgrasses showed little reduction in frequency and vigor following burning, with greatest vigor following late summer and early fall burns. Cheatgrass showed no significant reduction in ground cover following spring burning, although the number of viable seeds per area was reduced.

Several shrubs sprouted prolifically following crown removal by fire, including chokecherry, bitter cherry, elderberry, green and blooming rabbitbrush, and horsebrush. Some shrubs sprouted conditionally. Up to 20 percent of bitterbrush plants sprouted on plots burned at different times of the year. Gray rabbitbrush sprouted prolifically on late summer burns, but almost not at all on spring burns. Big Sagebrush would not sprout following crown removal but would seed in quickly where a seed source remained.

Annual herbs usually became prominent in burned areas, especially whitestem mentzelia, phacelia, alfilaria, and several mustards.

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PRESCRIBED FIRE EFFECTS, CRATER LAKE NATIONAL PARK

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The effects of autumn prescribed fire on old-growth ponderosa pine forest vegetation were investigated in Crater Lake National Park. Within the Pinus ponderosa-Purshia tridentata habitat type, stand structure and local fire history were determined through analysis of increment cores and of fire scars and ring counts in basal wedges from old trees. A 3000-acre burn, named Timber Crater-East, was conducted in the area during October, 1978, under a variety of weather conditions. Fire behavior and fuel reduction were correlated with fuel and weather variables measured at ignition time. Spread of the fire was dependent on the density and spatial arrangement of several shrub species, among which Purshia tridentata is most abundant. A 75-year fire suppression policy had resulted in the development of a dense understory of stagnated ponderosa pine in the area. The prescribed fire thinned this understory and created a more open, park-like condition. Local fire intensity, bark and foliage scorch, and cambial girdling were important factors. Coverage of Purshia tridentata decreased substantially, but sprouting and rodent seed caches enable this species to recover. The applicated of prescribed fire is discussed as a tool in restoring the natural role of fire within this habitat type.

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FIRE ECOLOGY AT BANDELIER NATIONAL MONUMENT

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The role of fire in the ecosystem has been of increasing interest. For nearly 70 years a policy of total fire suppression was followed by Bandelier National Monument. The lack of fire resulted in dangerously high fuel loads. As a result, in 1976, a study to provide baseline data for a fire management plan was initiated. The study included a determination of fire frequency prior to total fire suppression and plant succession as related to fire. Fire frequency was determined by fire scar dating and plant succession by utilizing areas known to have previously burned from 1-99 years. This baseline study was near completion (June 1977) when a conflagration, the La Mesa fire, burned 15,270 acres and swept over the previously established plots.

To determine the influence this fire had in the area of known fire history, the plots were examined in respect to the amount of foliar singeing sustained during the La Mesa fire. The resulting data showed that with the increasing length of time since the area had burned prior to the La Mesa fire there were increasing amounts of foliar damage. Areas which had not burned within the last 27 years showed nearly complete tree kill. Analysis of fire scarred trees revealed a fire frequency with an average interval of 17 years and a range of 8-27 years. Much of the area, however, had not been burned for over 82 years. This data substantiated the findings from the analysis of fire scorched trees as related to fire history and provides a case for more frequent fire.

A continuing successional study has examined the recovery and delayed mortality of these stands two growing seasons post-fire. Parameters included previous fire history, density of trees living after the fire, fuel loads, competition with herbaceous vegetation and size class as related to either improvement or deterioration in the foliar vigor.

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HUMAN IMPACT ON NATURAL RESOURCES

PLANT SUCCESSION AFTER TRAMPLING IN FOUR HIGH ELEVATION PLANT COMMUNITIES OF OLYMPIC NATIONAL PARK

SCHREINER, EDWARD

Plant succession following two types of trampling disturbances was examined in subalpine and alpine communities of Olympic National Park. Permanent plots were established and vegetation sampled so a better understanding of the rates and processes of change could be obtained.

Three communities receiving controlled trampling treatments in 1972 were monitored. A moist Antennaria lanata community exhibited the most rapid recovery. A cushion plant dry meadow had a complete rearrangement of community structure two years after trampling. Collinsia parviflora, a native annual, achieved dominance after being present in only trace amounts before the trampling.

An alpine zone parking lot was also examined. Line intercepts in a grid were set up as a permanent vegetation monitoring system following closure of the lot in 1973. Achillea millefolium, a known colonizing species, dominated for the first two years but has been replaced by Festuca idahoensis. The relationship between an introduced and native grass invading the parking lot was also explored.

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SOIL SENSITIVITY AND RESOURCE MANAGEMENT OF THE ALPINE TUNDRA, ROCKY MOUNTAIN NATIONAL PARK, COLORADO

SUMMER, REBECCA M.

Concommitant with increasing population in the urban corridor of the Front Range, Colorado has seen a surge in recreational activities in the mountains. Intense impact upon the previously undisturbed terrain is apparent as more remote areas are penetrated, particularly the land above treeline. Severity of degradation of the alpine landscape is dependent upon soil properties rather than vegetative cover because even low intensity use often results in exposure of soils to erosion. Therefore, erodibility, the inherent physical property expressing soil susceptibility to erosion, was studied in the alpine tundra of Rocky Mountain National Park by simulating conditions where vegetation has been removed by hiking, grazing, fire or road construction.

A portable rainulator was used to simulate rainfall at an intensity of 16 to 18 centimeters per hour for 90 minutes at 160 field sites. Results of the experiments indicate that erodibility indices -- grams of detached soil per unit of simulated rainfall -- range from 0 to 36 grams over a variety of soils. Seven replicate rainfall experiments are required to estimate a mean erodibility index within 5 grams. Soil sensitivity ratings -- relative rankings of soils based on erodibility indices -- correlate strongly with topography and vegetation. The within group variability in erodibility is expressed spatially within less than 30 centimeters and this spatial heterogeneity is characteristic to all the soils.

These findings demonstrate that alpine soils cannot be considered as one type of soil, but rather as diverse soils exhibiting highly variable responses to surface disturbances. The sensitivity rating system is useful for evaluating land use compatibility with different parts of the landscape. The extreme spatial variability at the microtopographic level suggests that any use which disrupts vegetation will probably result in maximum soil erosion. Therefore, protective management must focus on a site specific basis when planning conservation measures.

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VEGETATIVE CHANGE AND VISITOR USE IN A SUBALPINE MEADOW, YOSEMITE NATIONAL PARK, CALIFORNIA

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The correlation of known numbers of park visitors in a given area per unit time with species and community response is a prerequisite for determination of ecological carrying capacities in national parks.

One widely used method for determination of ecological carrying capacity for backcountry meadows is to study similar areas in which the vegetation is in equilibrium with known, but different, levels of historical and current visitor use. Another common approach to determine ecological carrying capacity is to subject a previously undisturbed area to known and controlled levels of use and compare species or community response, as a function of use, to an undisturbed control area. This method is used primarily when historical use levels cannot be determined.

This study presents results which show, for a subalpine meadow in Yosemite National Park, California, which is in equilibrium with historical and current use levels, how simple and standard methods of community vegetation analysis based upon Greig-Smith's coefficient of community determined from cover, density, frequency, and importance values yields a correlation with human trampling and soil compaction. Such a correlation may be used by park managers to predict the effects of trampling on the meadow community. It is also shown that for predictive purposes it is more useful to use coefficient of community calculations based upon the community attributes cover, density, frequency, and importance values instead of individual species attributes when attempting to correlate community response with visitor impact.

Results are also presented which show the effects of visitor use levels on vegetative community attributes and soil compaction for a previously undisturbed subalpine meadow which was not in equilibrium with visitor use levels. Data indicate that quantitative measurements of cover, density, frequency, and importance values as used in coefficient of community calculations predict an erroneously high carrying capacity level. It is suggested that casual observations by a trained individual may yield more accurate carrying capacity predictions for vegetative communities that are not in equilibrium with visitor use than do quantitative coefficient of community calculations.

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MEASURING IMPACTS OF VISITOR USE ON BACKCOUNTRY CAMP AREAS

MACLEOD, SUSAN A.

Concern over the impact of increasing levels of recreational use on backcountry areas has led to the implementation of such use restrictions as trailhead quotas, zone quotas, designated campsites, one night camping limits and limits on party size. In order to be effective such restrictions must be based on a thorough understanding of the nature and extent of visitor impact in a given area. In Sequoia and Kings Canyon National Parks, we have developed and are now applying a system to evaluate the impact of recreational use on wilderness lands as reflected by backcountry camp areas. The system, which is easily applied, provides a basis upon which to make management decisions as well as a baseline against which to evaluate future change.

The Camp Area Inventory system uses primarily visual criteria to describe individual campsites as well as evaluate how they differ from the "near natural" conditions of their surroundings. Each campsite (any site showing signs of being used for overnight camping) is mapped and rated for eight biological or physical impact indicators. These include measures of the size of the site and its barren core, density, composition and mutilation of vegetation, presence of litter and duff and such developments as fire rings, windbreaks and social trails. The distance to water as well as the number of sites in close proximity are also recorded. The mean rating of each campsite then determines to which of five impact classes that site belongs. The classes are assigned weighted values which are summed by camp area (all sites around a given lake or stream segment) to provide a synthetic measure of impact. Each camp area is evaluated for vegetation type, elevation, distance from trailhead and trail access. A linear estimate is also made of total campable terrain as a basis for evaluating the area's ability to accommodate different use levels.

The impact data can be analyzed by individual campsites, by camp area or by larger travel zones. It provides a comprehensive description of the nature and extent of backcountry impact which can then be related to known use levels. Correlations between use and impact as a function of such variables as elevation, community type and distance from trailhead provide an effective basis upon which to make informed management decisions. The system appears to be especially well suited for backcountry areas with numerous undesignated campsites widely dispersed over remote terrain.

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ASSESSING THE IMPACT OF VISITOR USE ON VEGETATION AND SOILS OF SAGUARO NATIONAL MONUMENT

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Medium scale aerial photographs have been taken of the Rincon Mountain Unit of Saguaro National Monument, Tucson, Arizona at irregular intervals during the last twenty years. These photos provide an excellent source of data on which to base a management policy on use of a lowland area susceptible to soil and vegetation damage by excessive use.

Without some sort of historical perspective, it may be difficult if not impossible to document in a short time subtle or cumulative effects of visitors on the natural resources of an area. The question of how quickly areas in the Sonoran Desert recover from the impact of human or domestic animal use is hotly debated. In years with abundant rainfall at the proper season, growth of annuals and luxuriance of perennials is impressive; however, records from the Mojave Desert indicate that heavily disturbed areas in arid lands may show the signs of use for at least forty years. The problem of quantifying the recovery period can be approached by utilizing aerial photography in combination with ground studies of actual trail parameters.

Field work at Saguaro National Monument measured current trail width and depth and ranked trails according to the magnitude of the measurements. Indexed trails were then compared to recent aerial photographs to obtain a reference for matching the aerial view of any trail with its approximate ground measurements, and a map of the trails at a scale of 1:12000 was then produced. Comparisons were then made with older aerial photographs. Estimated trail indices and apparent trail changes were noted and a map compiled from the old photographs.

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VEGETATIVE STRUCTURE, PHYSICAL ENVIRONMENT AND DISTURBANCE IN WHITE SANDS NATIONAL MONUMENT, NEW MEXICO

REID, WILLIAM H.

White Sands National Monument occupies about 620 km^2 in the Tularosa Basin of southern New Mexico, and falls within the northern Chihuahuan Desert in floristic terms. The Monument is surrounded by limited access federal facilities. The western area is a Larrea-Prosopis upland, and the south and east margins are a plain with Atriplex, Sporobolus and Allenrolfea. The central areas of the Monument have several types of gypsum-substrate features. These include ephemeral lakes (Lake Lucero most notably), an elevated, stabilized area of 25 km^2 reaching 30 m above surrounding plains and dunes, a large alkali flat, an area of partially stabilized parabolic dunes, and, most striking, a transverse and barchan dune field. Both the macro- and micro-topography of the gypsum areas, together with vegetative structure, are determined by aeolian effects, ground water patterns and drainage. Great variation in soil chemistry exists despite a rather uniform appearance. Factors such as electrical conductivity, nitrogen, manganese, iron, zinc and phosphorous, for example, vary between 100:1 and 5000:1 from place to place. Much disturbance is visible within the Monument on close examination. The basin was settled by Europeans in the 1850s, and cattle raising with its attendant effects continued until formation of the Monument in 1933. During WW II initiation of White Sands Missile Range created substantial impact. Currently the major disturbances include some Missile Range activity, some unauthorized intrusion by ORVs, grazing of Oryx gazella within the Monument, visitor use and occasional feral dogs. Our analysis of the vegetation shows about 20 significant plant associations that can be related to soil chemistry and sand activity. These were determined using a fuzzy subset method relying on Braun-Blanquet's constancy and fidelity. Associations were related to environmental factors by Bray and Curtis ordination. Between transverse dunes and behind parabolic dunes there exists a measurable plant succession that has been difficult to relate to changing soil properties. The soil flora includes at least 310 microorganisms, and both lichens and mosses grow at the surface. This material often exceeds 1000 gm per m^2. The persistence of different forms of disturbance has been estimated. Work supported in part by NPS CX 702980023.

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A COMPARISON OF SURFACE IMPACT BY HIKING AND HORSEBACK RIDING ON FOUR TRAIL SURFACES IN GREAT SMOKY MOUNTAINS NATIONAL PARK

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The purpose of this study was to quantify differences between horse and foot impacts on trails in Great Smoky Mountains National Park. Four types of surfaces: pasture, foot trail, mesic foot and horse trail, and xeric foot and horse trail, were investigated for three types of impact: horse and rider (horse with steel shoes), hiker with lug soles, and hiker with flat soles. The trail sections used were measured off in transects of 50 to 100 meters and divided into 10-meter intervals. In the case of the open pasture, vegetation height and surface soil compaction were measured after 20, 50, 75, and 100 passes. In the case of the three types of trails used, measurements of surface compaction and depth of leaf litter were taken after 10, 20, 40, 70, and 100 passes.

In the pasture, hiking produced a doubling of soil compaction after 100 passes, whereas horseback riding resulted in a sharp increase in compaction after 20 passes followed by a decrease as the horse's hooves worked through the grassy root systems and began to break the sod. On the foot path, both hiker use and horse use significantly decreased the leaf litter and the compaction of the soil but horse use produced greater change in soil compaction than foot use. Mesic trail sections showed a much quicker change in surface condition than the xeric sections under horse use.

Determining relative carrying capacities for foot and horse users has to be accomplished relative to trail surface and moisture conditions. Our data, however, suggest that a ratio of 2.5:1 or 3.5:1 might be used for dry compact surfaces (horse pass: foot pass relative trail impact), and a ratio of 6:1 or 8:1 for new, loose, or very wet surfaces.

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VEGETATIVE AND SOIL RESPONSES ON THE APPALACHIAN NATIONAL SCENIC TRAIL

SPENCER, EDWARD L. and ROGER J. STEARN

This paper summarizes a series of studies undertaken by the Research Department of the Appalachian Mountain Club on the vegetative and soil responses on a heavily used backcountry trail, the Appalachian Trail in New Hampshire and Maine. The purpose of this paper is to provide an integrated picture of trail corridor responses. Alpine tundra, boreal and northern hardwood ecosystems have been studied. Results show severe vegetative damage and very slow recovery in alpine ecosystems, while there is a net positive response to the trail by ground vegetation in the boreal and hardwood zones. Soil loss was related to site factors such as slope, elevation and vegetation type as well as age of trail and trail maintenance techniques used.

Vegetative responses vary significantly according to elevation. In alpine tundra ecosystems substantial areas have been denuded of vegetation by foot traffic. These remain unvegetated because of frost action (diunal surface movement measured at as much as 3 cm), poor seed germination and poor seedling survival. Field analysis identified pioneering species, seeds collected showed germination rates on a temperature gradient bar in the laboratory as high as 88%. In the field germination attained only 38% for the best sites, however. Survival rates of seedlings in the field were less than 10%.

At lower elevations transect measurements showed a varied response by native ground cover species. These were related to canopy cover, light intensity, air and soil temperatures. Species such as Coptis groenlandica, Cornus canadensis and Maianthemum canadense showed increased occurrence near the trail compared to the undisturbed forest. These species show a heavy investment in vegetative growth and appear to benefit from the intermittent disturbance within the trail corridor.

Ultimately the well-being of the trailside plant communities depends on the stability of the trail. Transects were established across the trail to measure long term vertical and horizontal displacement of the trail trough itself. Newly established as well as older trails were measured. Results showed major displacement of soil in the construction process and continued instability three to four years after, even with carefully implemented stabilization techniques. On older trail sections disturbance was lower. Percent slope and length of slope above the transect were identified as major causes of trail instability.

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PROBLEM ASSESSMENT AND VEGETATIVE REHABILITATION OF VIEW POINTS AT BRYCE CANYON NATIONAL PARK

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Increased visitor use of scenic view areas at Bryce Canyon National Park, Utah during the last several years has caused soil compaction and vegetation damage increasing soil erosion and decreasing aesthetic quality. Soil infiltration rate, soil bulk density, sediment production and vegetation cover were used to assess the degree of disturbance at the view points. Container-grown native plants were used to revegetate the disturbed areas. After touring the Park, three view points were selected for soil and vegetation analyses and plant establishment studies. High-use and low-use areas were identified within each selected view point. One non-use area was analyzed for comparison purposes. Soil bulk density and sediment production were consistently greater on high-use areas compared to low-use areas. Soil infiltration rates and vegetation cover were lower on high-use areas compared to low-use areas. The low infiltration rates and high sediment production on the high-use areas were attributed to the lack of vegetation cover and plant litter. Foot traffic was the cause of the increased soil bulk density of the high-use areas. The soil and vegetation parameters for both the low-use and non-use areas were similar. Plants native to the Park were propagated from seeds and stem cuttings. Plants were then grown in containers for a fall, 1978 and spring, 1979 planting at three view sites. The shrubs planted during fall, 1978 were low sagebrush (Artemisia arbuscula), manzanita (Arctostaphylos patula), bitterbrush (Purshia tridentata) and common juniper (Juniperous communis). Survival in June, 1979 was 61, 78, 65 and 86 percent respectively, for low sagebrush, manzanita, bitterbrush and common juniper. These same four shrubs, with the addition of indian ricegrass (Oryzopsis hymenoides) were planted in spring, 1979.

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HUMAN TRAFFIC AND RESPONSE OF BEACH VEGETATION AT APOSTLE ISLANDS NATIONAL LAKESHORE

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Shorelines of Great Lakes Apostle Islands are mostly precipitous sandstone cliffs or clay banks. Visitors can land safely only at a few beaches and sandspits on these islands. Consequently, these focal landing sites are beginning to show the effects of human traffic. Vegetation is particularly affected at mooring sites, campsites, and trails to areas of specific interest.

The National Park Service began monitor response to beach vegetation to human trampling in 1978 and plans to continue monitoring on limited basis in the future. Methods used to collect base data and initial results are described. Mitigation of vegetation damage through visitor management is discussed.

Plants dominant on relatively undisturbed beaches appear to be most vulnerable to trampling; Ammophila breviligulata and Deschampsia flexuosa are two of these that are closely tied to the beach association. Both species are on Wisconsin's list of rare and endangered species.

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CADES COVE, AN OVERVIEW; THE IMPACTS OF AN AGRICULTURAL AREA WITHIN A NATURAL AREA

BRATTON, SUSAN
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WHITE, PETER

Agricultural management in Cades Cove, an historic district in Great Smoky Mountains National Park, has affected natural resources both within the district and in the adjoining natural areas. In order to preserve the historic scene, haying and cattle grazing have been permitted under leases in an area of about 900 ha. Aquatic impacts from agricultural management have included increases in water temperatures, turbidity, nutrient loading, and bacterial counts, and decreases in benthic macroinvertebrate density, diversity, and fish biomass. Wildlife populations, including ground hogs, wild turkeys, and white-tailed deer, have increased in the open fields and around the historic district. Utilization by livestock had a greater impact on woodlots in Cades Cove than utilization by deer and reduced plant species number and stem counts in all strata sampled. Intensive deer foraging reduced species number, removed deciduous seedlings and samplings from woodlots and favored conifers in the 3-cm-dbh and smaller stem size classes. Although the open hayfields and pastures supported many species of exotic plants including crab grass and clover, invasion of the surrounding woodlots by exotic plant species did not appear to be a major problem. Cades Cove has a number of limestone habitats unique in the Park and both deer browse and cattle grazing may have disturbed populations of uncommon plant species. Effects of water quality deterioration are detectable at a campground 15 stream kilometers from the agricultural area, and effects of deer foraging extend about 1 km above the open fields.

Since historic landscape preservation is presently a goal of the Park, managing for open vistas in Cades Cove will require some sort of continuing disturbance. Managerial options grade from intensive agricultural use to some form of retarded old field succession, with little human interference other than occasional mowing or burning.

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A CASE EVALUATION OF EXCESSIVE BIVOUAC USE, ROCKY MOUNTAIN NATIONAL PARK

TIPTON, WILLIAM M.

A bivouac site was evaluated for excessive environmental impact through visual survey, user contact and bacteriological testing methods. Surface waters leaching through the site were analyzed for fecal coliform and fecal streptococci and subjected to the FC:FS ratio technique to identify human versus other animal forms of contamination. Soil analysis for *Clostridium perfringens* were conducted to identify previous fecal contamination. Climbers and climbing Park Rangers were questioned about their use of the site and opinions relating to aesthetic and potential health problems. A survey of the site, including photographs, was conducted.

Fecal coliform and fecal streptococci levels at points below the bivouac site averaged 5.6/100 ml. and 4.7/100 ml., respectively. The FC:FS ratio technique did not confirm either contamination from human or non-human sources, but rather fell within the range that is considered insignificant. A differentiation of the species of a single sample of fecal streptococci revealed 20% *S. faecalis*, 72% *S. faecium*, 4% *S. faecalis var. liquifaciens*, and 4% which did not grow upon subculturing. Soil samples taken at the site were positive for Clostridium perfringens, thus indicating the possibility of past fecal contamination.

The information and opinions obtained from climbers and Park Service personnel, and from on-site surveys, revealed an aesthetically unfavorable condition and a potential health problem. A management action to reduce the numbers of users has been implemented.

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THE INFLUENCE OF MODERN MAN ON THE STREAM SYSTEM OF YOSEMITE VALLEY

MILESTONE, JAMES F.

This research paper reveals modern man's misguided improvements to a pristine stream system within a national park; a park, originally designed to preserve the natural processes. The research calls attention to the geologic, historic, and present state of condition of Yosemite Valley's stream system. Starting in 1879, a campaign was launched to control the 47 miles of streams on the valley floor, in order to prevent destruction to real estate. Successful attempts to lower the water table by blasting the El Capitan Moraine dam stimulated stream degradation. By 1977, the river had down-cut an average depth of 4.5 feet. By 1970, over 14,000 feet of stream bank revetment had been installed throughout the stream system. Gravel which had been excavated from the river channel could fill eight trains. Eight massive concrete, false-stone arch bridges constrict the streams process of lateral migration. From such research findings an effective, yet practical restoration program for Yosemite Valley's stream system may be initiated.

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FIREWOOD GATHERING IMPACTS IN BACKCOUNTRY CAMPSITES IN GREAT SMOKY MOUNTAINS NATIONAL PARK

BRATTON, SUSAN
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During the summer of 1978, .1 ha vegetation survey plots were established in eight backcountry campsites; one plot was established in the center, one in the transitional area (if it existed), one in the firewood gathering area, and one in a nearby control area which had little human impact. Two of the campsites were in spruce-fir and were occupied by trail shelters. Three of the sites were in mature hardwood and three were in successional forest and were open campsites. Stem numbers, basal area, and species diversity were obtained for both canopy and understory of all plots. Firewood fuels were estimated using U.S. Forest Service techniques for determining densities of 1-hour, 10-hour, and 100-hour fuels. Additional measurements included number of live trees, number of stumps, and soil compaction. The data indicate that canopy opening is more prevalent in some sites than others, the spruce-fir forest showing the strongest trend toward complete absence of canopy-sized trees at the center of the site. Reproduction of tree species does not appear to be inhibited by firewood gathering without intensive human trampling. Reduction in the basal area of standing dead wood varies with the type of site. Older growth stands are less depleted, presumably because some of the stems are too large to cut easily with hand tools. Fuel loadings decreased from the controls to the firewood gathering areas to the trampled center of the sites. Different size classes of the fuels were differentially affected by firewood gathering and trampling activities, the smaller fuels being more strongly affected by trampling and little impacted by firewood gathering. Availability of larger size classes of fuel varied with the forest type. Other impacts included a tenfold increase in the number of injuries to trees from the control areas to the center of the sites.

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THE ENVIRONMENTAL IMPACT OF LECONTE LODGE, GREAT SMOKY MOUNTAINS NATIONAL PARK

NICHOLS, ROSEMARY

Closing LeConte Lodge, a 22-building backcountry concession on the summit of Mt. LeConte, was proposed as a part of the National Park Service wilderness recommendation for Great Smoky Mountains National Park in 1974. To provide additional data for planning and management, field studies conducted in 1976 were directed toward assessing cumulative environmental damage attributable to Lodge operations.

Using infrared trail traffic counters, 1976 summit visits were estimated as 28,000-32,000. Day hiker use was about three times LeConte Lodge guest numbers, which average 8,000 per six-month season. Despite high levels of visitation, potentially impacted streams exhibited a pattern of low background coliform counts and occasional moderate contamination typical of most park waters.

Changes in plant communities were of three types: (1) destruction of ground cover, (2) displacement of native species by disturbance-adapted exotics, and (3) reduction in canopy coverage and loss of understory trees. The Lodge complex had more than 20 times the vegetation and soil damage of a nearby Adirondack shelter sustaining 3,000-4,000 overnights annually. Other adverse concession impacts included trampling of rare plants and provision of artificial food sources that attracted panhandler black bears.

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AN ECOLOGICAL ASSESSMENT OF BISCAYNE NATIONAL MONUMENT'S CORAL REEFS IN RELATION TO RECREATIONAL USE

TILMANT, JAMES T.

The ecological impact of recreational activities on coral patch reefs at Biscayne National Monument have been studied for two years. Reef fish, macro algae, macro invertebrates, coral damage, and chemical and physical parameters of four heavily used coral reefs marked with buoys have been compared to four similar unmarked control reefs. Significant ecological impact from present use has not been found.

Species/time random counts have revealed 203 fish species on the reefs studied. One-way ANOVA has indicated significant seasonal variation in both species richness and relative abundance of fish. Between individual buoyed reefs and their controls, only two had significantly different changes in fish species richness. In both cases, the buoyed reef increased in species while the unmarked reef decreased. A marked seasonal variation in species composition and abundance of the macro algal communities was observed. Overall, algal communities comprised approximately 20 percent of the reef surface. Community composition of the macro algaes has consisted of 16 Chlorophyte species, 5 Phaeophytes and 9 Rhodophytes. Number and abundance of Phaeophytes was greater in summer than winter. Rhodophyta have shown an opposite trend. Macro reef invertebrates were sampled utilizing line and line-plot transects. Octocorals comprised an average of 82-87 percent of the coral abundance. Mean overall density of octocorals was 27.4 colonies/m^2. Scleractinian corals averaged 7.5 colonies/m^2. Non-coral macro invertebrates averaged 8.6 individuals/m^2.

Boat groundings appear to be the most severe human impact on Biscayne's coral reefs. Four observations of severe coral damage resulting from boat groundings have been made on the reefs studied. Damage resulting from boat anchors and swimmer activities does not appear significant. Repetitive time surveys have revealed no marked difference in incidence of coral damage between buoyed and unmarked control reefs. Coral damage is correlated to seasonal periods of high winds. Physical and chemical analysis of water surrounding the study reefs have revealed typically low nutrient levels with no evidence of pollutants.

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HUMAN IMPACT ON NATURAL RESOURCES/ORV's

OFF-ROAD VEHICLE USAGE ON FEDERALLY MANAGED COASTAL PARKLANDS

PALMER, J. F. and S. P. LEATHERMAN

Every year our coastal areas attract millions of vacationists. Among the more popular areas are those managed by the Federal government. Although this recreation demand is growing, little systematic research has been conducted investigating the scope of management concerns and the extent of social, biological and physical environmental impacts. This is particularly true of off-road vehicle (ORV) usage, which is proving to be one of the more pressing management problems of the 1970's. The National Park Service Cooperative Research Unit within The Environmental Institute at the University of Massachusetts conducted a preliminary survey to increase our knowledge in this area.

A detailed questionnaire was sent to all known Federally managed natural preserves and recreation areas with apparent coastal access. The rate of response was an encouraging 70 percent. The survey investigated four distinct topic areas: (1) The general context within each park including visitation pattern; the physical resource base; common types of recreation use; pressing management issues; and perceived research needs. (2) The characteristics of ORV users including demographic differences from other recreationists; reasons for ORV usage; and the types of ORVs used. (3) The types of impacts associated with ORV use including those to other recreationists; those to the natural environment; and an overall estimation of the compatibility of ORV usage with the park's existing management plans and policies. (4) The ways in which ORV's are regulated including the types of regulations used; their effectiveness; and methods of enforcement.

The results of this survey indicate that these coastal parklands share many of the same management concerns and are experiencing similar social and environmental impacts. Over 90 percent identified resource protection as one of their most pressing management issues. However, it is interesting to note that over 80 percent indicated that research into the social aspects of ORV usage is most needed to improve their park's management.

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OFF-ROAD VEHICLE EFFECTS ON DUNES AND MARSHES OF CAPE COD NATIONAL SEASHORE, MASSACHUSETTS

BRODHEAD, JOHN AND PAUL J. GODFREY

A four year study on the effects of off-road vehicles has been completed. The nature and extent of ORV damage on coastal systems relates most closely to the stages of plant succession, exposure to wave and wind energy, and level of impacts. At the start of the study, which involved a standard ORV, impacts were delivered to beach, dune, and marsh environments on a controlled basis. Rates of vegetation breakdown during the impact period, and recovery over a four year period, were monitored. Sensitivity indices were determined for the various plant communities, relating to actual plant survival and regrowth, and the tendency for drivers to travel in certain zones. On the beach-dune system, ORV impacts can markedly reduce the ability of Ammophila to expand from existing dunes, or to start anew in drift lines. Heavy traffic on the high beach, or through overwash passes (less than 50) can cause nearly maximum damage to vegetation. Continued use can lead to barren, migrating dunes. Given protection, recovery is most rapid on the foredune edge, less rapid on the rear dune; impacts there are still visible after four years. ORV impact is most long-lasting on Hudsonia vegetation.

Impacts in the salt marsh showed that open, barren flats can be maintained by continual ORV use; when protected, marsh vegetation rapidly developes on such flats. Impacts of less than 100 passes in the low marsh create havoc with the Spartina alterniflora community by destroying the peat layer, but recovery occurs in four years. Most serious ORV damage occurs between the high marsh and the dune edge, a region where ORV drivers tend to travel. Such use creates open, eroding borders that damage both the upper salt marsh and the adjoining dune zone.

It is recommended that ORV traffic be eliminated wherever possible on coastal systems such as those studied on Cape Cod. Necessary ORV traffic should be restricted to the open, intertidal beach away from driftlines, expanding dunes, and overwash passes. Ramps should be built over dunes where access to the beach is through dunes. Carefully managed tracks through a dune zone can be designed to cause minimal damage, if wind erosion, and free wandering of drivers, can be controlled. All ORV use on intertidal sand flats and salt marshes should be eliminated.

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EFFECTS OF OVERWASH AND OFF-ROAD VEHICLES ON BARRIER BEACH MIGRATION: NAUSET SPIT, CAPE COD NATIONAL SEASHORE

LEATHERMAN, STEPHEN P.*; ZAREMBA, ROBERT E.**; GODFREY, PAUL J.**

Nauset Spit is retreating landward by inlet dynamics and overwash processes. Salt marshes have developed principally upon flood tidal delta deposits, but overwash has resulted in substantial barrier widening in some areas. The short-term, rapid landward migration of Nauset Spit is controlled by overwash since, at most, three cycles of inlet migration have affected the area since 1620. Vehicles are accelerating this rate of retreat through disruption of dunes and thus enhancement of overwash. Vehicular passages across the dunes, without ramps, rapidly result in devegetation and blowouts. A high, natural dune field can be truncated in this fashion within a few years with continued ORV usage. These artificial dune breaches serve as overwash channels during storm conditions which results in an acceleration of beach erosion and overwash deposition and hence barrier migration. In addition to vehicular cuts perpendicular to and thus through the dunes, ORV sand roads have been established along the backside of the foredunes. In this case the dunes are being truncated on their advancing lee side. Without permitting the dunes to naturally shift landward and with continued seaside erosion, the demise of the foredune is ultimately insured. Finally, vehicular traffic through existing washover fans greatly hinders new dune development. Drift lines, which contain the rhizomes of American beach grass (Ammophila), are the precursors of new dunes. This drift material is deposited with the overwash sand during and following coastal storms. At the early stages of growth the new drift line plants are somewhat inconspicuous and very sensitive to even light vehicular traffic. ORVs effectively prohibit new plant growth on the old washover fans, resulting in the long-term continuance of the washover features and the lack of development of new barrier dunes. Where uncontrolled, vehicles are affecting the natural interaction between overwash processes and dune building on this northern migrating barrier beach.

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THE PREPARATION OF AN OFF-ROAD RECREATIONAL VEHICLE TRAIL MAP OF THE PROVINCE LANDS AREA OF CAPE COD NATIONAL SEASHORE

Benedict, Mark A., and Paul J. Godfrey

The Province Lands, a large natural area within the boundaries of Cape Cod National Seashore, is currently experiencing heavy visitor use pressure. The major visitor related impact is attributed to the many off-road recreational vehicles (ORVs) which frequent the area's beaches and sand routes. In order to document both past and present ORV usage, to establish the relative recovery rates of no longer used trails passing through different vegetation types and to evaluate the extent of recreational impact in this unique area, maps of both currently used and previously used ORV trails were prepared for the Seashore at a scale of 1:12000. In addition a map was made of the Province Lands' foot, horse and bicycle trails.

Map preparation involved two phases. Field reconnaissance consisted of visiting at least a part of all trails visible on 1:6600 black and white aerial photographs of the Province Lands and recording the vegetation type through which the trail ran as well as the trail recovery stage in each vegetation type. In addition all trails encountered in the field not visible on the airphotos were recorded for inclusion in the final map. Where possible information was obtained on the dates of closure for major inactive trails. The final maps were prepared using standard aerial photogrammetric techniques. The information was presented as a series of transparent overlays (active ORV trails, inactive ORV trails, foot, horse and bicycle trails) for a base map constructed from enlarged topographic maps of the study area.

In conjunction with a current vegetation map the Province Lands recreational trail maps provide a basis on which decisions regarding the area's management can be made. In the near future the entire ORV trail system of the Province Lands will be re-evaluated and new routes will be selected where necessary to minimize the adverse environmental impact associated with off-road recreational vehicle use.

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RECREATIONAL IMPACTS ON FOREDUNES: ASSATEAGUE I. NATIONAL SEASHORE

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During the past few decades recreational pressures on coastal ecosystems have greatly increased. These impacts can be grouped into two basic categories: pedestrian trampling and off-road vehicle traffic. Field studies at Assateague Island National Seashore have been focused on monitoring foredune vegetational and elevational changes in ORV-impacted, pedestrian-trampled and adjacent control areas. The elevational surveys showed that the foredune was in a natural stage of building or else relatively stable, except when impacted. Once a pathway has been established across the dune field, there appears to be a sequence of evolution. A small, initial V-shaped notch in the dune line will rapidly become a major blowout area with continued usage. It was found that elevational losses of 0.75 meters during a single year were common for pedestrian pathways. Where artificial dune breaches were oriented with the prevailing northwest wind, the rate of sand loss due to aeolian (windblown) transport was accelerated. Wind deflation of the devegetated pathways and trails resulted in complete truncation of the dune line in some cases. Several of these artificial dune cuts served as overwash channels during the winter storms, subjecting the backdune areas to salt water flooding and sand burial. It is interesting to note that ORV dune crossovers and well developed pedestrian pathways are similar scale features. These studies will aid in the formulation of management policies, including the use of structural controls for access (boardwalks and ORV ramps), to minimize recreational impacts on foredunes.

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RECOVERY OF OFF-ROAD VEHICLE DISTURBED ECOSYSTEMS: BEACHES AND GRASSLANDS

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Historical ORV usage of the eastern 11 km of Perdido Key, Florida, now part of Gulf Islands National Seashore, has resulted in a haphazard network of vehicular trails and tracks. Observations made during the 1978 growing season showed that above- and below-ground vegetation and root systems, respectively, were absent from marsh trails and from the Gulf of Mexico beach, possibly as a consequence of this vehicular travel. Our investigations showed that soil moisture content and degree of compaction differed between impacted and control areas; that vegetation density and above-ground biomass were greater in low impact areas; and that below-ground biomass varied inversely with impact. Vegetation along the sides of trails was either absent or stunted and of low density. However, root systems along the sides did not vary significantly from control areas. This situation is thought to reflect the intermittent, direct impact of the ORV and the sand laden swash produced by vehicles driven through water. Our studies show that during June, 1979, revegetation is occurring in locations now closed to ORV use. Along the margins of the marsh trails Hydrocotyle sp. is growing from the root systems covered by sand swash. Densities of 8 to 12 per m^2 occur where there had been none in April, 1979. Cyperus lecontei seedling revegetation is most evident in the main trail. Densities of 18 to 29 per m^2 occur where there had been no above- or below-ground vegetation or root systems, respectively. Gulf of Mexico beach transects from the primary dune to the berm crest show that Uniola paniculata seedlings are becoming established on the beaches, and the densities range from 0.73 to 0.83 per m^2. Hydrocotyle sp., both seedling and those vegetatively reproducing, occur in densities of 0 to 0.60 per m^2. In one area, transect counts made perpendicular to the main transect, 11.5 m from the primary dune toe, show densities of 1.42, 0.26, and 0.04 per m^2 of U. paniculata, Cakile edentula, and Hydrocotyle sp., respectively. The primary shoots of U. paniculata seedlings range in size from 1.5 to 33 cm long.

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STATUS OF STUDIES ON SEDIMENTARY AND BIOTIC PROCESSES AT PADRE ISLAND NATIONAL SEASHORE

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Observations were made over a four year period on sedimentary and biotic processes at Padre Island National Seashore. Data are presented on recreational and storm impacts on beaches with vehicle traffic and beaches with no vehicle traffic. There is a marked contrast in the characteristics of the two types of beaches. The beach with no traffic has developed mechanisms to thwart and buffer the effects that would tend to disrupt the stability of the system, whereas, the beach with traffic appears to be unstable and lacking these mechanisms. The two beach types are contrasted in a discussion of beach elevation, species richness, species diversity, vegetated beach width, species assemblages, and certain faunal units.

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OFF-ROAD VEHICLE IMPACTS IN THE BIG CYPRESS NATIONAL PRESERVE

CARLSON, J. E., M. J. DUEVER AND L. A. RIOPELLE

In order to develop a data base for decisions on the future role of ORVs in the BCNP, the National Park Service contracted the National Audubon Society Ecosystem Research Unit to evaluate ORV impacts and recovery rates in all the preserve's major habitats. During fall, 1978 we tested vehicles representative of the spectrum of types commonly used in the preserve (five types of swamp buggies, an all-terrain cycle (ATC), a track vehicle, and an airboat) in pine forests, open cypress forests, and marshes with three different substrate types (sand, marl, and peat) and determined the number of passes required for each vehicle to produce low and severe impacts. During the test runs, we also measured noise levels. After each run we estimated the depth of the resulting ruts, recorded visual impacts, and photographed the site both from the air and on the ground.

The following winter we made quantitative measurements of soil and vegetation impacts. Parameters measured included rut depth, percent cover, height, biomass, and understory species composition. We recorded visual impacts in ground-level photographs and determined mortality and recovery of shrubs and small trees.

Another aspect of the study involves monitoring the recovery of trails that have been in use for many years. We made the same quantitative impact measurements on old trail sites in pine, hammock, small cypress, large cypress, and marsh (three substrate types) habitats.

We are evaluating the effect of deeply rutted trails on natural surface water flows by measuring flows in trails passing through major drainageways or near canals and comparing them to flows in adjacent natural habitats.

We are also determining when and where different types of ORVs are used by periodic aerial censuses.

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ORIGINS AND DEVELOPMENT OF THE NATIONAL PARK IDEA

THE NATIONAL PARK IDEA: HISTORICAL MISCONCEPTIONS AND ECOLOGICAL REALITIES

RUNTE, ALFRED

Among both scientists and environmental activists, popular opinion holds that the national park idea evolved in response to environmental needs, broadly defined. But in fact national pride in scenic "wonders," not a concern for preserving wilderness and its diversity of wildlife and plant life, led Americans to establish the first national parks. Longing for some grandeur in the United States to equal the castles and cathedrals of Europe, writers and intellectuals turned to the architecture of nature. In 1864 Yosemite Valley was set aside, in effect the first national park, and in 1872 Congress established Yellowstone National Park. Yellowstone's great size, however, was a fortunate accident, the end result of concern about the region's yet undiscovered thermal attractions, not a deliberate attempt to protect the region in its full biological diversity.

The idea of preserving natural environments as well as scenic features came late in the national park movement, with the authorization, in 1934, of Everglades National Park in the wetlands of southern Florida. Similarly, not until 1935 did the National Park Service fully abolish its predator-control programs.

The protection of biological resources in the national parks today is still compromised by enduring perceptions of the national parks as repositories of natural spectacle, as areas to enthrall rather than instruct the visitor. Education of the American public to appreciate that all ecosystems have value remains the single greatest challenge to scientists and environmentalists alike.

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RESOURCE MANAGEMENT AND PLANNING

THE ROLE OF THE NATIONAL PARK SERVICE NATURAL RESOURCES (FIELD) MANAGER

WAUER, ROLAND H.

The National Park Ranger has long been responsible for the dual roles of resources management and law enforcement. For years the "man in green" was able to budget his time to do both jobs; law enforcement was only a fraction of what it is today, and resource management often was a matter of policing the environmental status quo. But, today things are different. The ever increasing workload and technology for managing and protecting park resources, visitors and facilities have greatly enlarged the task. When push comes to pull resources management becomes a secondary responsibility. The professional, multi-disciplinary Park Ranger has just about become an antique.

In a number of the larger and more progressive natural parks, resources management is recognized as a separate activity, and "Resource Management Specialists" are involved with resource management activities. But even then, the majority of those individuals specialize in only a few of the necessary elements, such as wildland fire, ungulates, caves, etc., not in the general management of natural systems. And often the park resource manager is a retreaded ranger or interpreter with little state of the art knowledge, and clearly lacks the background to coordinate a major park's resource management program.

An annotated listing of the various responsibilities is an initial step in resolving this problem. The Natural Resource Manager's responsibilities are lumped into the categories of Resources Management Plans, Natural Resources Functions, Natural Science, Action Plans, and Special Activities.

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MULTI-AGENCY MANAGEMENT OF A COMMON RESOURCE (ELK)

DRIVER, CHAS. H. and BRADLEY, WILLIAM

Two federal agencies (National Park Service and the Forest Service) and a state agency (Washington State Game Department) were interested in managing a common natural resource -- a non-native elk herd. Each of these public agencies has different basic goals to accomplish in the managing of this common resource. The Forest Service was committed to managing its forest resources and supply needs for winter range habitat; the Washington State Game Department was interested in fostering the best huntable herd; whereas the Mt. Rainier National Park natural resource managers were interested in conservation of the delicate sub-alpine mountain meadows utilized as summer range habitat by the elk herd.

To accomplish the goals of the various agencies the National Park Service supported an extensive program of research to study (1) the impact of elk use on sub-alpine meadows, (2) the population dynamics of the elk herd and (3) the herd movements throughout the year.

The resulting information and agency cooperation has been used to formulate a program of elk herd management focused on limiting the untenable impact on the delicate sub-alpine meadows of critical concern to the National Park Service based on a proposed winter range management program by scheduling timber harvest and other forest management practices by the U. S. Forest Service, and the Washington State Game Department conducting a highly successful special high recreation quality controlled hunt to limit the reproductive potential of the herd.

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THE CONFERENCE CONCEPT IN PARK PLANNING

LEATHERMAN, STEPHEN P.*; DIAMONT, ROLF**; GREGG, WILLIAM***

A new approach for park planning and decision-making was tested by the convening of the Ocean Beach Conference at Golden Gate National Recreation Area in August 1978. Prior to this meeting, the National Park Service was being pressured by the City of San Franciso to allow for the construction of a large wastewater tank adjacent to Ocean Beach, a unit of GGNRA.NPS policy had not been clearly stated as a comprehensive public position, and the potential problems were not properly addressed. Among those issues not fully assessed were the following: seriousness of the beach erosion problem, possibility for future puncturing of the wastewater tank by storm waves and spewing of sewage onto the beach, and gradual loss of the beach and associated recreational values and opportunities. The issues involved in this controversy were complex; indeed the basic data sets were often misleading and usually incomplete. This conference brought together all of the experts (federal, state and private) who had studied this area, with NPS scientists, knowledgeable in the fields of coastal geology, botany and engineering, into a single panel for open discussion. The statement of findings and recommendations, prepared by the panel members, became the baseline document for all future consideration of this complicated problem. The consultation approach through the assembly of an expert panel proved to be invaluable in this case and should receive much broader usage. It is an excellent vehicle for defusing controversy and arriving at the best possible consensus on the problems, the facts relevant to their analysis, alternative solutions and their consequences, and providing recommendations for effective action. Since the conference is focused directly on the decision(s) to be made, this approach is likely to be more productive in finding a solution than a broad-purpose forum covering many issues.

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THE IMPORTANCE OF BIOTIC LISTS AND POPULATION INFORMATION TO RESOURCE MANAGEMENT

JOHNSON, R. ROY and LOIS T. HAIGHT

Composition of species lists is commonly one of the first steps in inventorying the natural resources of a Park Service area. Properly used, these lists play a key role in monitoring the biological health of the area and serve as an early warning system to changes within the ecosystem. Less often used but of even greater value is population density information, including general densities (relative or absolute) and trends for plants and animals within these areas. This type of information becomes increasingly important in keeping track of certain key species such as threatened and endangered or non-native species.

Formation of species lists is not as difficult as evaluating and monitoring population trends. Thus Park Service areas often at least have species lists for vertebrates and flowering plants. Monitoring population changes in all species is impossible within manpower and budgetary constraints. However, monitoring of selected species is an important tool for increasing the efficiency of resource management activities in National Park areas. Census techniques as well as means of recording road-kill information and wildlife observation data will be discussed.

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MULTIDISCIPLINARY APPROACH TO RESOURCES MANAGEMENT PLANNING FOR CHANNEL ISLANDS NATIONAL MONUMENT

FRIES, NANCY L. and Q. NICHOLAS WHELAN*

Comprehensive studies on natural (terrestrial and marine) as well as cultural (historical and archeological) resources of Channel Islands National Monument were undertaken as part of the General Management Plan (GMP). Recommendations that evolved from these studies form the basis for the park's revised Resources Management Plan which addresses biotic, physical, and cultural resources. Scientific information gathered by interdisciplinary teams shaped the sequence and priorities of the planning effort, provided a basis for daily management decisions, and expanded scientific knowledge of the islands.

Land use planning projects require a broad approach and the compilation of information from many fields. The preparation of a comprehensive plan provided an opportunity to gather information on a variety of monument resources. The use of an interdisciplinary team was particularly valuable because interrelationships between resources could be identified, researchers could share their knowledge with one another to their mutual benefit and to the benefit of the study, and recommendations for the management of closely related and proximally located resources were coordinated and compatible to one another. This study successfully demonstrated that interdisciplinary research, which resulted in a high quality product, is a desirable approach to future research at Channel Islands, as well as to research in other areas with large numbers of sensitive and overlapping resources.

Scientific information affected planning for the islands, not only by indicating sensitive resources, but by becoming the basis of the plan and influencing the sequence of preparation of various components of the plan. The resources management component of the GMP was determined to be the most important. Therefore, a detailed Resources Management Plan established the framework for other plan sections and was completed before a compatible preferred visitor use alternative was chosen.

Park management needs were answered by the study because it provided a factual basis for daily management decisions, a monitoring base for repeatable data collection in the future, new information on the distribution, status, and habitat requirements of island species, and additional insight into the location and significance of cultural sites.

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MISSION ORIENTED RESEARCH IN NEWLY ESTABLISHED VOYAGEURS NATIONAL PARK

COLE, GLEN F.

A 891 km2 forest and lake area in Northern Minnesota was established as Voyageurs National Park in 1975. This park is within a southern boreal forest region along part of a historic waterway boundary between the United States and Canada. The park's legislatively-established mission is to preserve, and provide for the appropriate enjoyment of, examples of the regions scenic natural environments and native biota. Extensive logging and slash fires, complete and near extripations of faunal species, and manipulations of lake levels by dams occurred within the past 100 years. Comparisons of hypothesized natural conditions with present flora and fauna conditions indicated the ecological effects, or problems, that resulted from the above and suggested what actions are needed if the park is to accomplish its purpose. Only time, plant succession and natural disturbances appear to be needed to restore a natural forest vegetation. Reintroductions that establish viable woodland caribou (Rangifer caribou), moose (Alces alces) and/or elk (Cervis canadensis) populations appear necessary to restore a representative large herbivore and carnivore fauna, and prevent further declines, or displacements of rare or threatened species. The effects from using boundary lakes as storage reservoirs to generate electricity need to be communicated in a way that will allow an International Joint Commission to consider the relative costs and benefits of reducing the frequency of summer and fall floods and lessening impacts on aquatic plants, shore nesting birds, aquatic mammals and fish populations.

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PERSPECTIVES ON THE DEVELOPMENT OF ALTERNATIVES FOR A RESOURCE MANAGEMENT PLAN FOR INDIANA DUNES NATIONAL LAKESHORE

HENDRICKSON, WILLIAM H.

The General Management Plan for Indiana Dunes National Lakeshore, specifically requested by the Congress to be delivered to it in 1979 will include sections on visitor use and development as well as resource management. This pattern conforms to the Planning Guidelines for the National Park Service.

It appears that resource management will involve the political process and thus always include human decision making. There is not sufficient park territory at Indiana Dunes for natural factors to have their free territorial range. Indeed, many components have been lost from the ecosystem; this includes the larger mammals, the populations of native fish in Lake Michigan, and much of the natural vegetation.

Fire frequency has been manipulated; efforts have been made to drain the wetlands; erosion has been both accelerated and deterred by shoreline construction and landfill.

The boundary of the National Lakeshore is long and meandering for the expanse of territory which it contains. A full spectrum of technological impacts including heavy industry, highways, agriculture and residential use conflict with the park intent.

National Park Service Management Policies were reviewed so that alternative methods for managing the resources of this park unit could be described. In the public review, there has been support for and against the various alternatives which were recommended as the preferred ones.

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A CONCEPTUAL ECOLOGICAL MODEL OF GLACIER BAY, ALASKA AND ITS IMPLICATIONS FOR RESOURCE MANAGEMENT

WRIGHT, R. GERALD and LYNNE ZEITLIN-HALE

Glacier Bay is a spectacularly dynamic glacial fjord system located in Southeastern Alaska. The Bay has twelve major tributary inlets, six of which have tidewater glaciers, and is connected to the Gulf of Alaska via Cross Sound. Although Glacier Bay National Monument has received considerable scientific attention for close to 100 years most investigations have focused on the Monument's glaciers and terrestrial environment and little is known about the Bay itself. As human pressures on this rich marine system increase, an understanding of its ecological components and processes has become critical.

A conceptual ecological model of Glacier Bay's marine system was developed and used as the framework to 1) organize, summarize and synthesize information about the Glacier Bay marine system, 2) identify system components and processes subject to perturbations resulting from human activities, and 3) identify potential Park Service resource management actions and research priorities within Glacier Bay.

All available information on Glacier Bay including published reports, unpublished data and information obtained through interviews was collected. For system components where little or no information was available, data from other Southeast Alaskan fjords was cautiously used. Relationships among system components were largely inferred from work conducted in other similar environments.

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RECREATIONAL AND COMMERCIAL FISHERIES IN EVERGLADES NATIONAL PARK: AN ECOSYSTEM APPROACH TO RESOURCE MANAGEMENT

DAVIS, GARY E.

Everglades National Park coastal ecosystems are large, diverse, complex and support economically significant fisheries. A time-series of catch and fishing effort data spanning 20 years, climatological and hydrological records, and sporadic ecological studies are analyzed to determine the relative influences of natural environmental cycles, fishery harvest and other human activities. Six ecologically discrete systems ranging from 200 km^2 to over 650 km^2 comprise the 2,655 km^2 of coastal waters and mangrove lined estuaries in the park. Between 1962 and 1978, 125 to 276 commercial fishermen used the park annually. Recreational fishing activity increased steadily from 58,000 angler-days in 1959 to 174,000 in 1965, and fell to less than 100,000 by 1977. The principal species in the commercial fisheries are stone crab, spotted seatrout, white mullet, striped mullet, and Florida pompano. The recreational harvest consists primarily of gray snapper, red drum, spotted seatrout, and snook, but tarpon and bonefish are highly prized trophies sought extensively in the park, and another 12 species are commonly caught. Annual fishery harvests ranged from 986,000 kg to 1,920,100 kg from 1972 to 1977. Within the same ecosystem, catch rates revealed that red drum, spotted seatrout and gray snapper populations each responded differently to variations in environmental conditions, but species' responses varied between ecosystems during the same time period. There was a marked reduction in annual catch rate variations from 1959 to 1978. Red drum and gray snapper populations showed shifts in age structure from juveniles toward higher proportions of mature fish. Seasonal catch rates were apparently associated with spawning aggregations and drastic changes in environmental conditions. Since the existing fishery deals directly with only 21 of the 208 species of fish in park coastal waters, and increased fishing effort generally produced proportionally increased harvest throughout the range of effort observed from 1972-78, it appeared that management of fishery harvest would be largely ineffective in affecting either the fishery resources or the ecosystems in which they reside. Fish populations may effectively serve as indicators of biological conditions in coastal systems of the park, but efforts to manage them need to be concentrated on ecosystem level processes such as freshwater runoff and boating activity. Major changes are occurring in the distribution and use of freshwater in watersheds adjacent to the park, and local boating was directly associated with short-term decreases in catch rates in the park. The condition of fishery resources in Everglades National Park depends primarily on the management of its coastal and upland ecosystems.

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FISHERIES MANAGEMENT IN EVERGLADES NATIONAL PARK: SCIENTIFIC DATA AND PUBLIC INPUT

DAWSON, RICHARD H.

The recreational and commercial fishery in Everglades National Park represents a combined annual value of $3.7 million. Recently, the declining fishery harvests in the park and a general increased demand for recreational fishing opportunities have intensified competition and conflict between commercial and recreational fishing interests in the park. To further complicate the management of fisheries resources is the paradox for both wilderness preservation and continued fishery harvest. As a result, sport fishermen and professional fishing guides have questioned the current fishery management practices and policy of the National Park Service, particularly with respect to the use of nets and the unlimited harvest of game fish species in the park. To adequately address this problem, while complying with National Environmental Policy Act guidelines, we assessed the biological and socio-economic impacts of several alternative fishery management actions utilizing seventeen years (1959-69 , 1972-1977) of recreational fishing data based on about 100,000 personal interviews at selected boat ramp sites in and around the park, combined with commercial fishermen and professional fishing guide trip tickets adjusted by independent field observations of fishing activity, from 1972-1977. This data allowed an adequate estimate of a variety of parameters ranging from catch-effort statistics to actual value of the fishery. By actively soliciting public input through community workshops combined with our data base information, we assembled a fishery management plan and produced regulations which allow effective management of park fisheries, provide for the enhancement of the visitor experience, protect endangered species, and preserve the natural role of the marine areas of the park.

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APPLICATIONS OF A LARGE MAMMAL SYSTEM STUDY FOR NATURAL RESOURCE MANAGEMENT IN RIDING MOUNTAIN NATIONAL PARK, CANADA

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An integrated research program was initiated in Riding Mountain National Park in 1975 to provide natural resource data in an ecosystem context. The large mammal system study was composed of 2 major research elements; the wolf as summit predator in the large mammal food chain and the partitioning of habitat resources by elk, moose and white-tailed deer. Data were collected on other component species of the system including coyote, lynx, snowshoe hare and beaver. Temperature and snow data were acquired to provide an index of winter severity. In 1979 a natural resource management process was initiated. Utilizing data generated from the large mammal system study and other resource studies a Resource Description and Analysis and a Park Conservation Plan were prepared. Management of the natural environment from an ecosystem perspective is now possible because of an integrated research approach and application of a structured, standardized resource management process.

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ISLE ROYALE WOLVES AND NATIONAL PARK MANAGEMENT

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Isle Royale National Park, Michigan, supports one of two well established populations of eastern timber wolves in the United States and has been designated as "critical habitat" for this species. Wolf density on this island is currently higher than anywhere else in the world. For more than 20 years, these wolves have been the object of continuous research, which has documented the primary importance of wolf predation to the welfare and population dynamics of Isle Royale moose. A priority goal of park management is to protect wolf activity from human disturbance. Isle Royale wolves, by their very avoidance of humans, enhance the public perception of wilderness.

Relatively little wolf/human interaction occurs on the island, and wolves continue to exhibit pronounced avoidance behavior toward humans, even though totally protected during their 30-year history on Isle Royale. Research has documented wolf avoidance of hiking trails during the visitor season and the influence of human activity on the location of wolf dens and rendezvous sites. The influence of wolves on park management is discussed, including park management philosophy, campground and trail development, appropriate backcountry use, research techniques, and park closure during winter.

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RESEARCH AND MANAGEMENT OF BIGHORN SHEEP IN JOSHUA TREE NATIONAL MONUMENT

DOUGLAS, CHARLES L. and WHITE, LESLIE D.

Desert bighorn sheep in Joshua Tree National Monument are adversely affected by human encroachment and by decreasing water supplies. Over the past two decades, pumping of ground water and long-term drought have decreased the number of dependable springs from about 60 to 10. Combined efforts of researchers and managers are enhancing conditions for the bighorn herd.

Bighorn distribution and herd composition have been evaluated by means of helicopter surveys and time lapse photography at springs. Bighorn habitat has been mapped and composition of the vegetational communities quantified.

A telemetric study of movements has just been completed. Multivariate analysis of home range data were used to help determine placement of an artificial water source (guzzler) where it would have the highest probability of use by bighorn, and thereby increase use of potential summer habitat.

Management actions taken to ameliorate human encroachment on bighorn habitat have proven to be highly successful.

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BIOLOGICAL IMPACTS OF POLITICAL MISMANAGEMENT OF WHITE-TAILED DEER IN PICTURED ROCKS NATIONAL LAKESHORE

ROBINSON, WILLIAM L., LLOYD W. FANTER*, ALBERT G. SPALDING, AND STEVE L. JONES

In 1974 the National Park Service acquired 1200 acres in Beaver Basin as an addition to Pictured Rocks National Lakeshore. This included a wintering population of white-tailed deer (Odocoileus virginianus). Since 1960 the deer had been fed about 80 tons annually of commercial deer ration by the corporate landowners who managed the property as a private hunting and fishing retreat for executives and guests. This paper, based upon field studies done from 1974 to 1979, documents the impact of the high deer population on vegetation in Beaver Basin, recounts significant political and judicial decisions which prevented a controlled harvest of deer, and describes the rapid decline of this deer population upon termination of artificial feeding.

Through annual contracts with the NPS since 1974 we have conducted studies to assess the numbers of deer wintering in Beaver Basin, to describe their movements, their behavior, their mortality, and to estimate the production and consumption of browse. In the winters of 1974-75 and 1975-76, during which artificial feeding was continued on a reduced basis, estimates of 620 and 650 deer, respectively, were made. Starvation of up to 25 per cent overbrowsed vegetation was apparent. A special controlled hunt in early 1977 proposed by the Michigan Department of Natural Resources and the NPS to reduce the numbers of deer was opposed by a local sportsmen's club on the grounds that irreparable harm would be done to the deer population. They obtained a court injunction against the hunt, and they continued feeding deer for another winter.

Feeding was discontinued in the winters of 1977-78 and 1978-79, and losses by starvation and coyote (Canis latrans) predation took about 50% of the deer population each winter. In January 1979 the number of deer was estimated at 190, and the size of the winter range occupied was reduced by about half. Coyote populations, which have over recent winters thrived on the nutritional misfortunes of the deer, may continue to prey upon the deer to a greater than normal extent, but eventually a relatively stable population of 150-200 deer is predicted for Beaver Basin.

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AVERSIVE CONDITIONING OF *CAMPGROUND* COYOTES IN JOSHUA TREE NATIONAL MONUMENT

CORNELY, JOHN E.

In August, 1977, park rangers and monument visitors reported that several coyotes were begging for food from visitors in Hidden Valley Campground in Joshua Tree National Monument, California. The number of coyotes seen in the campground increased from three in August to more than 12 in November. Although Joshua Tree supports a large population of coyotes, large concentrations in or near campgrounds are unusual. The coyotes at Hidden Valley approached humans more closely than coyotes normally do in other areas of the monument. Because of this apparent lack of fear of humans, they posed a potential hazard to monument visitors. These coyotes were offered a variety of baits laced with lithium chloride in an attempt to discourage their scavanging in the campground and begging food from visitors. Illness induced by ingestion of these handouts appeared to be effective in dispersing the concentration of coyotes at the campground.

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AVERSIVE CONDITIONING OF BLACK BEARS IN THE BACKCOUNTRY OF YOSEMITE NATIONAL PARK

HASTINGS, BRUCE C. AND BARRIE K. GILBERT

Problems between humans and black bears have been increasing in the backcountry of Yosemite National Park in recent years. The major source of property loss in many areas has been food in stuff sacks hung from trees. One possible solution to this problem is to break the association between food sacks and positive reinforcement. Experiments to determine the effectiveness of this technique were conducted in Yosemite National Park using two yearling males. A three-percent solution of ammonium hydroxide in a plastic bag was placed inside food sacks in areas frequented by backpackers and bears. The bears were somewhat averted from the test sacks but continued to obtain food from other food sacks. Food sacks of varying size, color, and hanging method were then used in a similar area in order to measure changes in bear activity. Results and problems are discussed.

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TECHNOLOGY

SARRMC - A MODEL FOR INTRAREGIONAL COOPERATION

MC CRONE, JOHN D

The Southern Appalachian Research/Resource Management Cooperative (SARRMC) was organized in 1976 for the purpose of providing coordinated research, extension, and educational support of programs to achieve full benefits of Appalachian forests, wildlife, waters, wildlands and their associated resources for their cultural, social, commercial, economic, and recreational utilization and enjoyment. The present members of SARRMC are Clemson University, the National Park Service, North Carolina State University, the Tennessee Valley Authority, the U. S. Fish and Wildlife Service, the U. S. Forest Service, the University of Georgia, the University of Tennessee, Virginia Polytechnic Institute and State University, and Western Carolina University.

The activities of the Cooperative have included:

1) A special study entitled Priorities for Natural Resources Research: A Systems Analysis for Western North Carolina.

2) A western North Carolina Research-Resource Management Conference.

3) An analysis of Southern Appalachian stream management problems.

4) An analysis of management alternatives and their consequences with respect to the European boar in the mountains of North Carolina and Tennessee.

5) An analysis of wood energy research opportunities in the Southern Appalachians.

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TECHNOLOGY TRANSFER ASSISTANCE
U.S. FOREST SERVICE

OKEEFE, TIMOTHY G.

Technology transfer is a relatively new term for a process that has been in operation, at least informally, for a long time. Much of the value in a sound piece of research lies in the practical application of the idea to solve a real problem. Although our forest laboratories have an abundance of technical information, many potential users don't even know that this information is available. Therefore, there is today a very serious information gap between the laboratory and the consumer.

At both ends of the information equation there's a high rate of activity; a great deal of production on the laboratory side and a high degree of demand on the user side. The major problem in the information equation seems to lie in the bridge element between the research production and the users at the other end. Most frequently this information gap is a result of a lack of knowledge about the sources of technical information or a problem in translating technical jargon into useful material. For today's public, reliable technical information--in a usable format--represents a vital raw material for successful operation.

Communications and human understanding are undoubtedly the basis of good technology transfer. However, some of the "research" produced by sociologists in the area of technology transfer has little practical application. For most effective operations, a good technology transfer specialist must be academically well-trained and capable of relating to the daily problems of line operations. He must be a "diplomat" with the ability to sell a program and to carefully identify user groups for the technology transfer system.

In recent years, concern about practical use of forest and wood products research information has been increasing. For this reason, the U.S. Forest Service has formally established a new technology transfer program, as a staff unit in Washington. The purpose of this Technology Transfer unit is to provide guidance and assistance to Federal, State, and private organizations in more effectively distributing research results. Often fine research work is never published in a form that is most useful to the appropriate audience. More attention to the process of efficient technology transfer will mean that research results find a useful application.

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WINTER RESEARCH OPPORTUNITIES IN GLACIER BAY

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In Glacier Bay winter processes and conditions may actually dominate and characterize the environment. As shown by the experiences of several researchers, there is considerable potential for winter research in certain disciplines. In the earth sciences, basic meteorological and climatological, snow and mass movement studies are possible. In some areas, easier glacier travel and less meltwater make subglacial observations simpler. Winter observations and measurements on glaciofluvial systems are feasible, and because of fewer icebergs in some areas, bottom sampling and other marine observations including the use of SCUBA, are attractive. Ecological observations of plants and animals during the stressful winter conditions offer unique opportunities for study, and the potential also exists for sociological research in isolated communities.

One of the most recent projects involved an investigation of the feasibility of subglacial research. Reconnaisance study of a glacier cave in Burroughs Glacier indicated that ready access was possible and that dry conditions existed during part of the winter season. In addition to this project, winter ecological observations were made during regular staff patrols of the Monument.

Scheduling of support facilities including ships and living space is easier in the winter when there are fewer researchers; however, there are some disadvantages associated with winter research. Special equipment is needed for the cold and/or wet conditions that can exist during almost all winter months in any part of the Monument. Storms can cause more delays than usual, and researchers must cope with fewer hours of daylight. For those prepared for such problems, winter and off-season research offers the potential for significant results in certain disciplines.

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THE RELATIONSHIP OF NATURAL AREAS OR NATIONAL PARK LANDS TO OTHER NATURAL AREAS

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The National Park Service was one of the earlier agencies to establish "nature reserves" in an attempt to preserve natural ecosystems. Recent legislation has even declared the air over many National Park areas sacrosanct under this philosophy of preserving islands of our natural heritage for posterity. Better means need to be established for coordination of National Park Service activities toward preserving natural ecosystems in cooperation with other federal, state and private organizations.

Natural areas serve as controls against which to measure impacts of many human allied activities, e.g. water pollution, grazing, hunting, agriculture, urbanization and recreation. The ownership of these areas is of little consequence in the preservation of natural ecosystems. Evaluation of natural values should be independent of ownership constraints. Current land use practices and threats to native ecosystems should be assessed. The Arizona State Natural Areas Program will be discussed in relationship to areas on lands under the jurisdiction of the National Park Service and other federal agencies as well as related state and private activities.

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NURE AND THE NATIONAL PARK SERVICE

WEAVER, THOMAS A.

The Los Alamos Scientific Laboratory (LASL) is conducting a Hydrogeochemical and Stream Sediment Reconnaissance in the Rocky Mountain states and Alaska as part of the Department of Energy's National Uranium Resource Evaluation. Water and sediment samples are collected at one location every 10 square kilometers in the lower states and one location every 23 square kilometers in Alaska (with one location every 11 square kilometers being sampled in the mountainous regions). The LASL has sampled all of New Mexico, Colorado, Wyoming, and Montana as well as adjacent portions of Idaho, Utah, Arizona, Texas, and Oklahoma and approximately 75% of Alaska. Included in the lands sampled are the Yellowstone, Mt. McKinley, Glacier, Canyonlands, Grand Teton, Rocky Mountain, Arches, and Carlsbad National Parks, as well as numerous National Monuments and approximately 70% of the Alaskan lands proclaimed as interim National Monuments by President Carter in December 1978. Water samples are analyzed for 13 elements (including chromium, iron, manganese, nickel, uranium, and zinc) and sediment samples are analyzed for 43 elements (including aluminum, chromium, copper, gold, iron, lead, manganese, nickel, silver, thorium, titanium, tungsten, uranium, vanadium, and zinc). The elemental data, together with the field-measured data (e.g., ph, conductivity, etc.) provide a wealth of information relative to environmental pollution, strategic resources, geology, and geochemistry. These data can be used as background environmental data and also for aiding in determining the final disposition and boundaries of the interim National Monuments in Alaska.

The data from the Mt. McKinley and Talkeetna 1° x 3° National Topographic Map Series quadrangles, which include approximately 70% of the Mt. McKinley National Park and the Denali National Monument, have been examined in detail. Contoured plots of the concentrations of the various trace elements reveal the areas of base- and precious-metal mineralization in the quadrangles. In addition to the known mining districts (e.g., Kantishna Hills, Camp Creek/Little Mountain, Cache Creek/Petersville, etc.), several other areas in and on the flanks of the Alaska Range are indicated as containing potential reserves of strategic minerals. In addition, the concentration of lead in sediments in these two quadrangles is far lower than in comparable geologic settings in the lower states, suggesting that Alaska is as yet relatively free of pollution from automotive emissions.

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GROUND-BASED MONITORING OF PLANT AND ANIMAL COMMUNITIES

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Resource monitoring provides a continuous watch on renewable biological resources. Reliable sampling systems permit analyses on directions and causes of change, predict future resource levels, and alert managers to possible deleterious changes in environments that can affect plant or animal population levels. Our paper illustrates aspects of controlled sampling at the community level of biological organization. In order to achieve the above goals, ground-based monitoring can meet some exacting sampling requirements. Monitoring performance should distinguish real effects which are the actual changes in population levels from either natural or unnatural causes and apparent effects which are changes in population levels as the result of observation itself.

The statistical design of ground-based monitoring can be directed toward anticipated real effects often suggested by resource management policies. Major elements of the design necessary for quality control of data are: controls, calibration, sampling frequency, replication, and precision. Inattention to these elements may cause apparent effects to mask real effects. Monitoring systems including baseline measurement programs sometimes fail because of poor design. When subsequent plant or animal data are compared to the baseline the first question will be whether differences are real or artifacts. Controlled monitoring increases the resolution of small real effects in part by minimizing the magnitude of apparent effects.

This kind of ground-based monitoring can be a major tool to land managers concerned with the preservation of natural diversity, maintaining population levels in island-type preserves, assessing impacts from visitor use or management prescriptions, or periodic inventories for other purposes.

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ECOLOGICAL LAND CLASSIFICATION: AN INTEGRATED APPROACH TO LAND INVENTORY FOR POSSIBLE NATIONAL PARK MANAGEMENT OF THE INDIAN PEAKS WILDERNESS AREA

LUFF DAVID

Public Law 95-450 created the Indian Peaks Wilderness Area. At the present time the Wilderness Area is administered by the National Forest Service. Public Law 95-450 also directed the Secretary of Agriculture and the Secretary of the Interior to prepare a report for Congress studying and evaluating the suitability of revising the boundaries of Rocky Mountain National Park to include all or part of the Indian Peaks Wilderness Area. Based on that report, Congress will make a decision concerning possible boundary changes to the National Park. Ecological Land Classification is employed to inventory lands of the Indian Peaks Wilderness Area that have the potential to come under the administration of the National Parks Service.

The Ecological Land Classification approach to the collection and analysis of wilderness landscape data provides the National Parks Service with salient, comprehensive information about the Indian Peaks Wilderness Area not in a single disciplinary manner but in a form accentuating its ecological interconnectedness. Land Types, as expressed by the Ecological Land Classification, have differing use-limitations for differing wilderness land uses. Differing Land Types that have similar use-limitations for the same wilderness land use are grouped together. Units formed by the amalgam of Land Types that have similar use-limitations are called Ecologic Planning Units. Ecologic Planning Units foster an appreciation for the effects differing wilderness land uses may have on a specific wilderness landscape as well as the effect differing wilderness landscapes may have on a specific wilderness land use. By its integrative approach, Ecological Land Classification combined with the development of meaningful Ecologic Planning Units will provide Rocky Mountain National Park wilderness managers with basic environmental data that may be needed in the determination of future management policies and strategies for all or part of the Indian Peaks Wilderness Area. The Ecological Land Classification method of collating and analyzing environmental data for management purposes is not only applicable to the Indian Peaks Wilderness Area but to other Wilderness Areas administered by the National Parks Service as well as to the National Parks per se.

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BASIC ECOSYSTEM STUDIES OF THE INDIANA DUNES NATIONAL LAKESHORE

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The Indiana Dunes National Lakeshore at the head of Lake Michigan is a challenging resource for the region and the nation. It is in an area with potential for significant natural resource preservation and interpretation of the record of Great Lakes origin and evolution and the ecology and evolution of unique flora and fauna associations. Concurrently, the Lakeshore gives promise of becoming the site of extensive recreational activities, a "Gateway-Midwest", for the millions of metropolitan residents -- thus, of becoming a truly urban national park. The challenge to the National Park Service focuses on these dual purposes, preservation and appreciation of the natural resources and maximum development of the urban recreation potential. This basic ecosystem study provides data for a more complete inventory of the Lakeshore resources and aids the National Park Service in identifying the fragile areas in need of careful husbandry. These data should also aid other federal, state and local agencies in developing policies and programs in environmental management which offer protection for the Indiana Dunes National Lakeshore from pollution practices often expectable in urban-industrial areas.

There is a clear need for the establishment of an environmental quality and resources benchmark. The urban highly industrialized area continues to grow adjacent to the Lakeshore. Recreational, interpretive, and maintenance facilities are being planned and constructed within the Lakeshore. Will the quality of the environment change? What is the status of the environment in the natural areas of the Park? This study directs itself to the latter question and, hopefully, allows for continued collection of data and environmental monitoring pertinent to the former.

The study organizes in a comprehensive framework the natural history, land use, and selected environmental quality information relating to the Lakeshore. All data are depicted on or referenced to a photo and topographic base-map atlas having a scale of one inch equal to 4,800 inches and utilize mylar transparencies to facilitate the use of overlays. Inventories and analyses include: 1) settlement historical geography and land use; 2) terrestrial and aquatic plant and animal communities; 3) soils and geology; 4) climatology and air quality impacts; and 5) noise conditions.

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ENVIRONMENTAL EVALUATION OF THE BUFFALO NATIONAL RIVER USING THE GRABER METHOD

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There is a definite national need to develop and employ systems of environmental evaluation that are quantitative in nature and free from subjective bias. This study addressed the need by testing one such evaluation scheme, the Graber method, at the Buffalo National River, a relatively new national park where land management decisions are immanent.

The Graber method generates indices of habitat and biological quality that are based on quantitative analyses of biotic communities. These indices produce estimates of relative value of natural areas. The results obtained are essential to decisions concerning preservation, management, and development of such areas, which are important pending considerations for the Buffalo National River.

The study was confined to a region in the upper Buffalo National River that receives diverse impacts ranging from heavy to slight public usage. Popular visitor sites and vast primitive areas were included in the study tract. Not only was this an initial test of the Graber method in a situation where management policy is crucial, but an attempt was made to extend the Graber techniques beyond the biological base to include geological and archaeological aspects.

The project was interdisciplinary in involving personnel representing the fields of zoology, botany, forestry, geology, archaeology, mathematics, and geography. The results of the investigation showed the relative value of the visitor impact areas compared to the overall nature of the park as a whole.

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INVENTORY AND CLASSIFICATION OF SURFACE WATER RESOURCES IN GRAND CANYON NATIONAL PARK

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An inventory of surface water resources in an arid region is an integral component of any comprehensive resource basic inventory, or ecological survey, of the region. Development and application of a meaningful surface water classification system is essential for ease of data access and final application of results toward a solution of identified resource management problems or goals. Data presentation should recognize the needs of the National Park backcountry user and the functions of surface water related to support of the biota.

In the Grand Canyon, the availability of surface water is related to geologic structure, aquifer mechanics, seasonality, annual precipitation and other factors. Major geologic formations in which springs arise include the Muav limestone and Redwall limestone, while locally, the Vishnu schist, Tapeats sandstone, Supai formation and Coconino sandstone yield small quantities of water to springs. Intermittent streams predominate in the region, with the few perennial streams (with the exception of the Colorado River) being related to large spring systems on both the north and south sides of the Colorado River. Natural lakes have been formed by a number of large sinkholes which exist in some areas with a substrate of Kaibab limestone as examples of Karst topography. Playa lakes are rare. Artificial surface water sources include wells, improved springs, and catchment tanks.

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USING FIELD SURVEYS AND COMPUTER TECHNIQUES: A VISUAL RESOURCE INVENTORY FOR SHENANDOAH NATIONAL PARK

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Scenery can be inventoried, analyzed, evaluated, and classified despite its subjective nature. A wide variety of procedures are available, ranging from very descriptive inventory to highly quantified inventory combined by computer. Field surveys and computer methods each have their advantages and disadvantages. Used together, they can provide a quite complete inventory of visual resources. Such a combination was used for an assessment of alternatives for the Shenandoah National Park general management plan.

Shenandoah is a ridgetop park with a road throughout its 100 mile length, Skyline Drive. Views from this drive of blue ridges, hollows, farms, pastoral settlements, and the winding Shenandoah River are a rich blend of natural and cultural beauty, essential to the identity of the park. Changing land uses around the park threaten to degrade these views, so their protection is an important part of the assessment of alternatives for the GMP. Their inventory is a key part of the resource base inventory.

A total of 115 viewpoints were selected, including 70 overlooks along the drive, developed areas, high points, and points outside of the park. Areas which could be seen from these points were mapped individually using the VIS computer program, as well as the aspect of the seen area relative to the viewpoint. The VIS program also constructed a composite map of all the areas seen, which showed how many times each cell area was seen. Such a composite would be an unreasonable manual task.

Field surveys were conducted at 28 of the overlooks. Each of these viewpoints were surveyed with a plane table to map areas seen, photographed, and recorded on a survey form. This survey form was developed for Shenandoah to consistantly record the elements of each view. The plane table maps were used for checking and adjusting the computer drawn maps. The field surveys brought in details, learned significance, and descriptions of what the parts of the landscape contribute to the whole composition, information which is difficult to model with a computer.

The resultant data file of field surveys and computer generated maps proved to be valuable for developing planning alternatives, particularly the modification of land base through acquisition and scenic easements.

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DATA BASE BUILDING: PROSPECTS, PROBLEMS, AND PROMISE OF DIGITAL CARTOGRAPHY

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A digital cartographic data base is seen as an essential, though missing, component in the construction of an information base within the National Park Service. The immense utility of a digital cartographic data base for automated drafting, revising, scale changing, integrating, retrieving, storing, and analyzing mapped information would seem to justify the prodigious and frankly consuming efforts required for its development.

The problems in digital data base construction are formidable: digitizing, ascertaining hardware compatibility, selecting software and ensuring its intercompatibility, identifying file structures, and defining format and polygon codes. Sporadic, well-intentioned National Park Service efforts toward these ends over the last half-decade have resulted in the creation of bits and pieces of digital cartographic data-base management systems (DBMS's), but no consistent, unified nucleus of a digital cartographic data base itself has emerged. Impediments to progress in these areas include insufficient staff and hardware, the present capabilities of which are discussed.

Many agencies are currently building digital cartographic data bases; some of these, particularly those with potential utility to the National Park Service, are discussed. At the same time, many excellent DBMS's for digital cartographic data have been created. A system developed by the Fish and Wildlife Service appears to have all the capabilities the National Park Service needs--at least for the foreseeable future--and is available at no cost. It would seem quite logical for the Park Service to adopt this or some off-the-shelf package for its own use rather than to continue development efforts.

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CARPS-COMPUTER ASSISTED RESERVATION AND PERMIT SYSTEM

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Information provided by the wilderness permit system is often not an integral part of backcountry management decisions because it is considered a rough and unreliable estimate of visitor use and is not generally available on a timely basis. This paper presents a backcountry permit and reservation system that utilizes a minicomputer to assist in the issuing and handling of backcountry use permits. The objective of the system is to improve the current wilderness permit system so that it provides more reliable and accessible information for backcountry management at a cost comparable to the current mostly manual system.

The system was written in BASIC-PLUS for a Digital Equipment Corporation PDP 11/45 minicomputer running under the RSTS operating system. It is composed of three modules; CREATE, ISSUE and REPORT.

The CREATE module is used by park management to initialize and update trailhead and zone parameters. After the system has been initialized for a specific park, the CREATE module is used only if changes are necessary to existing trailhead quotas, trailhead or travel zone numbering schemes, etc.

The ISSUE module assists park personnel with the issuing of reservations and permits. The module checks the permit data for reasonableness as the data is entered into the system. It also determines the availability of permits and reservations for a given trailhead and date. Finally, this module prints out the standard permit or the reservation confirmation notice. Messages can be automatically printed on the appropriate permits to warn visitors of hazards in areas they plan to use.

The REPORT module allows permit and reservation statistics to be generated for trailheads and/or travel zones. It makes permit use information available on demand during or after the season for both visitor use and park management decisions. Also the permit data can be formatted for transmission to Boeing Computer Services and extensive standard analysis on the IBM 370.

An earlier version of the system has been demonstrated for Sequoia and Kings Canyon National Parks as well as for Yosemite National Park and Inyo National Forest. The latest version will be demonstrated at the conference.

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TECHNIQUES FOR PROVIDING INFORMATION TO HIKERS ON THE APPALACHIAN NATIONAL SCENIC TRAIL

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Visitors to backcountry areas of parks and forests often are unaware of the basic information which they need to ensure a safe and enjoyable recreational outing. Two techniques which have been tried for the Appalachian Trail and adjacent trails in New Hampshire and Maine have been an urban information center in Boston and a cooperatively managed trailhead information booth at the bottom of two popular access trails to the Appalachian Trail. These techniques have been evaluated to determine their effectiveness in providing hikers with needed information and to determine the total and unit costs of these techniques.

The headquarters of the Appalachian Mountain Club receives many requests for hiking information. These were tallied as was the information given, and the date of the planned trip. Recipients were recontacted after the planned date of their trip to determine how useful they perceived the information to have been and what problems they encountered. Concurrently, a sample of hikers on and near the Appalachian Trail were contacted to determine what information sources they had used and what additional information they felt that they had needed. Results showed a wide diversity in information sources and significant variation in information sought.

An information booth was established on a popular access trail to the Appalachian Trail. It was cooperatively operated by the Appalachian Mountain Club, the US Forest Service and the New Hampshire Division of State Parks. During the summer as many as 375 individuals were contacted per day. Half of these occurred on weekends. A self-administered questionnaire was used to determine reactions of hikers to the booth. Over 80% had stopped at the booth for information. Most had asked for weather information; one-third had requested trail information. Seventy two percent felt that the information which they received was accurate, while 5% felt that it was inaccurate. Amortized annual cost per contact was 78¢ in 1977 and 48¢ in 1978.

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INFORMATION GATHERING FOR VEGETATION PRESERVATION MANAGEMENT: A CASE STUDY MUIR WOODS NATIONAL MONUMENT

MCBRIDE, J. R., and D. F. JACOBS

A methodology was developed for establishing the information base required for vegetation preservation management. The steps involved are (1) classify and map present vegetation by use of aerial photography and ground checking, (2) carry out field surveys to determine age structure and fire hazard of vegetation classes, (3) determine natural fire frequency, (4) perform search of historical records to determine past human impact, (5) present for each vegetation class summaries of past history, future successional potential, and fire hazard. Justification for our methodology is discussed. A case study of Muir Woods National Monument using this methodology is presented.

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TERRESTRIAL BIOLOGY: BOTANY, COASTAL BIOLOGY

A PHYTOSOCIOLOGICAL STUDY OF HORN AND PETIT BOIS ISLANDS, MISS.

Eleuterius*, Lionel, Caldwell*, John, and Shabica**, Stephen.

The floristics and plant ecology of two barrier islands (Horn and Petit Bois) off the coast of Mississippi were studied from 1976 through 1978. These islands are part of Gulf Islands National Seashore. A total of 283 species of vascular plants were collected from Horn (260) and Petit Bois (87) islands. Plant communities were delineated into marsh, meadow or high marsh, beach and relic dunes and woodland. Vegetational composition of each plant community was determined, with marshes having the greatest diversity of species (69) and relic dunes the least (30). Vegetational maps were prepared in color and acreage of respective plant communities determined. All insular plant communities have microenvironments and variations from the predominant vegetational type. No significant difference in the floristic composition of plant communities was found on eastern, central and western portions. Horn Island has over twice the area of Petit Bois Island. About 30% of Horn and 27% of Petit Bois islands are covered by beach dune vegetation. Very little woodland is found on Petit Bois Island (13.7 acres) in comparison to 469.5 acres on Horn Island. The average life span of pine trees on Horn Island lies between 30 and 40 years of age. Live oaks were found only on Horn Island, where about 40 mature trees and many young ones occur. Successional relationships between plant communities appear to depend on elevational changes produced by sand deposition or erosion and modification of land configurations. Protection from airborne sand appears to be the most important factor accounting for habitat stabiltiy. The rooting of plants by hogs and nutria and grazing of aerial plant parts by rabbits were not found to have a significant effect on the vegetation. Hurricanes and storms have catastrophic effects on the insular vegetation due to direct forceful impact and flooding. Peculiar shrub grazing was observed and rabbits suspected, however, no evidence was obtained. Fire has no detrimental effects on the vegetation if allowed to occur frequently. The absence of fire may result in meadows becoming shrub thickets. Accumulated plant materials in woodlands provides fuel for the chance occurrence of devastating fire which could destroy mature pines. Alleopathic (inhibitory) potential was demonstrated by Solidago pauciflosculа but not for Ceratiola ericoides of relic dunes.

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VEGETATIVE ESTABLISHMENT ON AN ARTIFICIAL BEACH

Davis, Stephen and Wood, William

Establishment of vegetation on the duned Lake Michigan coastline of Indiana Dunes National Lakeshore has not proceeded as expected, following placement of artificial beach nourishment. This nourishment was placed to mitigate severe erosion of the dunes and total denuding of the beach by a combination of recent high lake levels and storm events. The beach fill, composed of glacial till, had a positive influence in controlling coastal erosion, due to an unexpected cementation of the material, which made it highly resistant to wind and wave erosion. However, this induration adversely affected the expected vegetative establishment sequence. Lack of a loose surface material, needed by pioneer vegetation to successfully be introduced, prevented the immediate start of sand capturing grasses. Only wasteland plants, well adapted to hard soil environments, first invaded this artificially stabilized beach. These wasteland plants dominated the fill for several years, with almost no new dune forming activity.

The eventual appearance of a few isolated pioneer grasses on the consolidated fill finally initiated embryonic dune growth. These dunes rapidly expanded horizontally, aided by vegetative stabilization, while continuing sand capture allowed vertical growth of the dunes. Presently these dune structures have matured beyond the pioneer plant stage, evidenced by the presence of secondary plants, adding to the diversity of species and consequently to the biological stability of the new dune system. The unnourished areas adjacent to the fill exhibited a totally different sequence of plant establishment, indicating the unique influence of this artificial beach on vegetative establishment.

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GEOBOTANICAL (VEGETATION AND STRATIGRAPHY) STUDIES IN CAPE LOOKOUT AND CAPE HATTERAS NATIONAL SEASHORES, N.C.

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Continuing studies of the ecology of barrier islands were conducted using simple techniques to obtain geological cores of Holocene sediments and relate them to existing vegetation at coring sites. Cores and vegetation data were taken on Shackleford Banks, Portsmouth Island, Ocracoke Island, and Hatteras Island. Cores up to 3 m long were obtained with PVC pipe driven down by a lead weighted hammer, then extracted with a heavy duty truck jack. Core samples were transferred to a second, split, tube from which fiberglass peels were made and samples taken for size analysis and shell identification. Vegetation at each coring site was sampled by a point-intercept method using a 0.25 m square frame placed above the vegetation. Cover and frequency data were obtained for all species present in the randomly located quadrats.

The initial results showed that all sediment sampled are of marine origin since they contain strata at various depths, including the base, that are dominated by oceanic shells and thus indicate overwash or old inlets. Vegetation, when present, was dominated by overwash adapted species, particularly Spartina patens. These results correlate exactly with similar studies done by the senior author on Core Banks, and support the idea that recent oceanic events (overwash and inlet changes) have played, and are likely to continue playing, a primary role in the structure and function of large sections of the Outer Banks. If the past is a key to the future, then management decisions regarding National Park Service operations on barrier islands of the type studied should be made with such findings, and others, in mind. The evidence is clear, after years of study, that the Outer Banks, and similar barrier islands, are migrating and have been substantially affected by overwash in the past, and are likely to be so affected again in the future regardless of human attempts to prevent such events.

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THE ECOLOGY OF SPARTINA PATENS AND ITS RELATIONSHIP TO THE MANAGEMENT OF EAST COAST BARRIER BEACHES

Benedict, Mark A., and Paul J. Godfrey

Spartina patens, salt meadow cordgrass, is a common coastal plant occurring along the Atlantic and Gulf coasts of North and Central America. S. patens' importance in the East Coast barrier beach ecosystems is tied to its ability to grow rapidly through overwash sand deposits to form new dense grasslands. In this way overwash fans on the rapidly retreating barrier beaches of the middle Atlantic are quickly revegetated and therefore stabilized by S. patens. The response of S. patens to overwash burial however varies with habitat, latitude, depth of burial and season of burial. This variation in response is related in part to differences inherent in the two currently recognized forms of S. patens. The ecological status of these two forms, the environmental factors determining their distribution and the exact cause of observed differences in their overwash recovery is not known and therefore the topic of our research.

The ecology of S. patens is being investigated in a three year research project at study sites located in Cape Cod National Seashore, Massachusetts, Assateague Island National Seashore, Maryland-Virginia and Cape Lookout National Seashore, North Carolina. Research conducted at these sites include: (1) quantitative vegetation and environmental analysis; (2) simulated overwash sand burial experiments; (3) growth pattern analysis; (4) food reserve determinations; and (5) isozyme analysis.

An understanding of the ecology of S. patens and its role in the ecosystems of East Coast barrier beaches is important in the long range management of these dynamically stable but everchanging coastal landforms. This plant could serve potentially as an important management tool on rapidly retreating barrier beaches once more is known about the latitudinal variation in the importance, distribution and overwash response of the two forms of Spartina patens.

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THE PLANT COMMUNITIES OF SANDY HOOK, NEW JERSEY WITH EMPHASIS ON *ILEX OPACA*

STALTER, RICHARD

The plant communities of Sandy Hook, New Jersey were studied from 1977 to present. Four major plant communities exist at Sandy Hook. These communities are the salt marsh community, located on the bay side of the hook; the sand dune community bordering the ocean and extending to the northern terminus; a mixed shrub community located on a system of old dunes; and an American holly (*Ilex opaca*) community located near Spermaceti and Horseshoe Coves.

The salt marsh community is dominated by *Spartina alterniflora*. Other species include *Salicornia* spp., *Limonium carolinianum*, *Suaeda linearis*, *Distichlis spicata*, *Spartina patens*, *Iva oraria*, and *Baccharis halimifolia*. Tidal flooding and soil salt content affect the distribution of salt marsh species. *Ammophila breviligulata* is the dominant species of the sand dune community. Salt spray is the most important factor affecting species distribution in the sand dune community. Other dune species include *Solidago sempervirens*, *Hudsonia tomentosa*, *Rhus radicans*, *Andropogon scoparius*, and *Myrica pensylvanica*. The mixed shrub community includes *Prunus maritima*, *Prunus serotina*, *Amelanchier canadensis*, *Rhus radicans*, *Myrica pensylvanica*, and *Ilex opaca*. The *Ilex opaca* community exists on a 30 hectare tract near Spermaceti and Horseshoe Coves on the oldest land at Sandy Hook. *Ilex* will probably remain dominant because of its isolation, its shade tolerance, and resistance to salt spray.

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A NORTHERN COASTAL PRAIRIE REMNANT ON POINT REYES PENINSULA, CALIFORNIA

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Although northern coastal prairie is presumed to have occurred on the Point Reyes Peninsula it has not been documented in the literature this far south. Over a century of grazing and "pasturization" has repressed and swamped natural communities of native grasses and forbs at Point Reyes. However a small stand of coastal prairie dominated by Deschampsia holciformis has been located on the Tomales Peninsula along the trail to Marshall Beach. The large variety of native forbs suggests that the site has not been grazed for a number of years. But the presence of large numbers of the introduced Plantago lanceolata and the small annual grasses Aira caryophyllea and Briza minor indicate that grazing by livestock was an important factor in the past land use of this area.

The site was thoroughly collected over the spring growing season. Some of the more interesting components of the spring flora include Orthocarpus densiflorus, O. pusillus, O. lithospermoides, Platystemon californica, Wyethia angustifolia, Acaena californica, Baeria chrysostoma, Polygala californica, Brodiaea terrestris, B. laxa, Calochortus tolmiei, Oenothera ovata, Lotus formosissimus, Gentiana oregana, Viola adunca, and Corethrogyne californica. A quantitative analysis was made of the vegetation to provide baseline data for future management that hopefully will increase the frequency and density of native species within the area and extend it along the periphery. Six 20 meter line transects were set up and the vegetation sampled every second meter along the lines. Over 75% of the cover was provided by just three species: Deschampsia holciformis (42.6%), Plantago lanceolata (18.4%), and Aira caryophyllea (15.9%).

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ONE HUNDRED YEARS OF PLANT SUCCESSION ON A CRATER FLOOR IN HAWAII

SMATHERS, GARRETT

In 1974, a volcanic eruption in Keanakakoi Crater, Hawaii Volcanoes National Park, destroyed a vegetation that had been forming on the crater floor since 1877. Analyses made of the vegetation in 1941 and 1969 provided further information on the rate of species invasion, composition, and community development of vegetation on lava flows in the montane seasonal forest of Hawaii. A hypothetical projection of time required for forest climax is proposed.

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AN ANALYSIS OF THE DISTRIBUTION OF NATIONAL PARKS AND OTHER RESERVES RELATIVE TO VEGETATION TYPES IN CALIFORNIA

KLUBNIKIN, KHERYN

The distribution of national parks and other reserves relative to vegetation types in California was investigated. Individual park units were small, an average size of 1,841 ha, and were widely distributed throughout the state. However, they were not equitably distributed relative to Kuchler vegetation types. There was a tendancy for all the reserve management systems to concentrate preservation efforts on one or two vegetation types. The private systems were much more efficient in preserving diversity than the national parks and other federal reserves.

Mojave creosote bush, Sonoran creosote bush, Sierran montane forest and upper montane-subalpine forest were the most extensively preserved types. Plant types of coastal areas, the Central Valley, and the rarer types receive little or no preservation effort. The overall ecological diversity of California is not represented in its park and reserve systems.

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SEED FLUXES AMONG EVERGLADES ECOSYSTEMS

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The successional vegetation on extensive areas of former farmlands in the Everglades National Park includes a substantial number of well-dispersed exotics that may invade surrounding mature communities if these are disrupted. Seeds from successional communities are better dispersed than those of mature communities. The limited dispersal of seeds from mature to successional communities results in slow succession after the first three years. Communities with well developed structure, such as dense forests, receive few seeds from outside. Communities with little structure, such as glades and early succession, receive substantial inputs of seed from surrounding communities. Seasonal flooding reduces viable seed inputs and seed storage in the soil.

We monitored the rain of seeds into nine Everglades communities: three mature (pineland, glade, and broadleaved forest), and six successional (3 to > 30 years). Seed inputs ranged from < 100 to nearly 3500 per $m^2 \cdot month^{-1}$. The number of species captured per site ranged from 8 (mature, broadleaved forest) to 19 (ecotone between 3- and 5-year-old succession). Of 45 species trapped, 24 were captured only one site; three taxa were captured on all nine sites.

Seed storage in the soil was determined on fourteen sites including those where we measured seed inputs. Soil seed storage values ranged from < 100 seeds per m^2 in two mature ecosystems (pineland and broadleaved forest) to nearly 8000 per m^2 in three-year-old successional vegetation. The number of species whose seeds were stored in the soil ranged from four (pineland and broadleaved forest) to 19 (three-year-old succession). Of 37 species stored, 12 were recovered from only one site; 1 was found in nine sites; and none were recovered from all fourteen sites.

Calculated turnover times for seeds ranged from about two weeks in the undisturbed pineland to over nine months in a middle-aged (ca. 15 years) woodland. Turnover rates on all sites are remarkably rapid, suggesting that succession may be markedly influenced by short-term opportunistic seed influxes.

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POST-FIR SUCCESSION IN THE BOREAL FOREST OF ISLE ROYALE NATIONAL PARK

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The prevailing forest type in the park is the boreal forest. This study determined some of the major changes that take place in the forest from the young pioneer tree stage to maturity. The results showed a trend toward increased density of shade-tolerant tree species and a decline in shade-intolerant species. Total relative density of coniferous species increase. There is a trend toward increased inflammability of the forest.

About 250 plots were set up, each in a stand whose age was determined by increment borings of the larger trees. For each plot the density of important tree species, tree reproduction, ground cover, soil litter depth, and the amount of wood, rotted or otherwise, on the forest floor (mostly from windfalls) was determined. Balsam fir and white spruce tend to increase with time while birch and aspen decline. The combined density of aspen, birch, and jack pine (all shade-intolerant species) declines while that of fir, spruce, and northern white cedar (all shade-tolerant species) increases. The combined density of spruce, fir, cedar and pine (all conifers) increases with time while that of aspen and birch decline. Soil litter depth increases very rapidly at first and very slowly after about 200 years. The amount of wood on the forest floor behaved in a similar fashion. The increase in conifers, soil litter depth, and wood on the forest floor all contribute to increased inflammability of the forest.

Among the ground cover species, wild sarsaparilla, (Aralia nudicaulis) and big-leaf aster (Aster macrophyllus), two of the most abundant ground cover species showed little trend while many of the less abundant species proved to be good indicators of either mature or immature stands.

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STUDIES OF THE PHYSIOLOGICAL ECOLOGY OF DESERT ANNUAL PLANTS IN DEATH VALLEY NATIONAL MONUMENT

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The climate of Death Valley National Monument is extreme and imposes unusual stresses upon the plants native to this region. The summers are extremely hot with temperatures in excess of 50°C (122°F). The winters are cool with occasional frosts. Mean annual rainfall is only 45 mm, and conditions are normally quite arid. We have conducted studies of the ecological, physical, physiological and biochemical characteristics of plants native to Death Valley with the objective of discovering and understanding the mechanisms which enable these plants to cope with this extreme environment.

The winter annuals which in favorable years produce spectacular floral displays are especially interesting. These plants germinate during the coolest periods of the year and there is a steady increase in environmental temperature during their growth season. Early in the season plant growth may be limited by low temperatures and occasional frosts, while late in the season temperatures may be so high as to be lethal to most other plants.

We report here studies of a mechanism which in part give these plants the capacity to adjust to the changing growth conditions which they experience. We have found that the characteristics of cellular membranes of these plants are such that these plants can tolerate the early-season temperatures and that the plants apparently modify their membrane characteristics during the season in such a way that they can tolerate the high temperatures of early summer without damage. The characteristics of these membranes have a dramatic impact on the photosynthetic processes of the plants. Photosynthetic responses to temperature are modified to suit the plant to thermal conditions as the season advances. Similar changes are also noted in the photosynthetic responses of evergreen perennial plants which are active throughout the year. Plants which might lack this capacity to adjust to the changing thermal regime would have a more restricted growing season and lower productivity than these plants which are adapted to Death Valley.

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TRACE ELEMENT CYCLING IN GRAND CANYON NATIONAL PARK

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Thirteen sites in the Grand Canyon National Park have been studied in an effort to define the variables that affect natural trace element levels in Gutierrezia sp. (snakeweed). The plant density was measured at each site and the vegetation was classified according to the scheme of Brown and Law. Samples of Gutierrezia sp., water and soil were collected at each site and analyzed for major anions and cations and the trace elements of zinc, iron, copper, manganese, vanadium, nickel lead, cadmium, and chromium. The chemical data was then analyzed to determine statistically significant correlations between trace element levels in the sample of Gutierrezia sp. and local geological, hydrological and soil parameters. The sites chosen for this study include: Hance, Cottonwood, Pipe, Garden, Horn, Salt, Monument, Hermit and Boucher Creeks from the South Rim and Bright Angel, Tapeats, Thunder and Deer Creeks from the North Rim. Preliminary results indicate rather large differences in the trace element compositions of soils and plants between sites, although all sites are rather similar geologically and biologically. The chemical composition of the soil appears to have the largest effect on trace element levels in Gutierrezia sp., with high trace element levels in the soil resulting in high levels in Gutierrezia sp.

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SOILS ASSOCIATED WITH PRAIRIE AND FOREST PLANT COMMUNITIES IN THE BALD HILLS OF REDWOOD NATIONAL PARK

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The Bald Hills comprise a large part of the land area which was added to Redwood National Park by Congress in 1978. In the Bald Hills, the California coastal prairie community and the Pseudotsuga-hardwood forest community occur together in a complex mosaic on the landscape. Currently the coastal prairie community is being invaded to a considerable extent by the Pseudotsuga-hardwood community. The purpose of this study is to examine and compare the soils associated with these two plant communities in order to discover whether soil variability is a major causal factor in determining the nature of the interaction between them. Preliminary analysis of the data indicates that soil is a major causal factor in many cases.

Ten pairs of study sites were established, each pair consisting of one site on the prairie and one site in the adjacent forest. In choosing sites, factors such as elevation, topographic aspect, and slope were held constant within each pair. At each site the vegetation was characterized, a soil pedon was described, and soil samples were collected from each soil horizon. Following laboratory analysis, prairie and forest soils were compared with respect to 1. soil pedon morphology, 2. concentrations of plant nutrients and other important chemical factors, and 3. plant available water holding capacity.

Morphologic characteristics of soils of the prairie and forest communities are generally quite similar, except for drainage. All of the forest pedons and half of the prairie pedons are well drained. The remaining prairie pedons are either moderately well drained or somewhat poorly drained. It is concluded that moderately impaired drainage is often an important factor in favoring prairie vegetation over forest vegetation in this area.

Chemical analyses of the soil samples reveal some minor differences among soils of the different vegetation types. In some cases it is felt that the differences are not causal factors, but rather occur as a result of the different vegetation types.

Plant available water holding capacities of the surface 60 cm of soil do not vary consistently with vegetation type.

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PINUS BALFOURIANA IN THE KLAMATH MTNS. AND IN SEQUOIA-KINGS CANYON NATIONAL PARKS

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The two allopatric populations of Pinus balfouriana, foxtail pine, are distinct in many characteristics of the foliage, bark, cones, and seeds. With respect to some of these characteristics, the population in the southern high Sierra Nevada, largely within Sequoia-Kings Canyon National Parks, is more similar to P. longaeva than to the northern Klamath Mtns. population; other features of Sierra Nevada P. balfouriana are intermediate between Klamath Mtns. P. balfouriana and P. longaeva. In recognition of the distinctness of the southern population of P. balfouriana, a new subspecies is described, to include all P. balfouriana in the southern high Sierra Nevada.

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THE INSTABILITY OF THE CONIFER SPECIES WITHIN THE FOREST-TUNDRA ECOTONE, NIWOT RIDGE, COLORADO

HANSEN, KATHERINE

Vegetational ecotones, which may provide initial indications of a changing climate and environment, should be closely monitored by the resource biologist and biogeographer. Vegetational ecotones, composed of an intermixing of two vegetational ecosystems, shift in altitudinal or latitudinal direction, responding to ecosystem changes. One such vegetative ecotone, found within the Rocky Mountain National Park of Colorado, is the forest-tundra ecotone, composed of krummholz conifers interspersed with herbaceous and woody tundra species.

An intensive study of this forest-tundra ecotone has been carried out within an area directly south of the National Park, the Indian Peaks Wilderness Area. The future long-range management by either the U.S. Forest Service or the National Park Service is presently under discussion.

The objectives of this study are to determine the relative stability of the forest-tundra ecotone, its' susceptibility to disturbances, the ability of the conifers to regenerate, and what climatic conditions appear to be controlling its present altitudinal range. Data sources include tree-ring and age structure analysis, physiological-response monitoring, water stress, and micro-climatic measurements. The forest-tundra ecotone has also been carefully mapped in geographic extent during the construction of the Indian Peaks Environmental Atlas, funded by NASA-PY, Grant # NGL-06-003-200, at the Mountain Research Station, through the Institute of Arctic and Alpine Research at the University of Colorado, Boulder.

The forest-tundra ecotone within this study area appears highly stressed. Results of this study include: a) all growth above the winter snowpack is killed by dessicating winds, blowing ice and sand particles, and low temperatures, b) seedlings have established within the lower zones of the ecotone, although there is almost no conifer regeneration at the upper treeline edge, c) air temperatures indicate cool summers which prevent adequate cold-hardy development against -40°C winter temperatures and which inhibit adequate cuticular development against dessicating winter winds. Disturbances to the ecotone by fire, wood-gathering, and trampling are rarely repaired.

Reccomendations are made that a detailed management plan within the National Park, and especially within the adjacent and newly designated Wilderness Area, be developed for the forest-tundra ecotone.

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CLONAL SENESCENCE AS A FACTOR IN THE POPULATION DYNAMICS OF AMMOPHILA BREVILIGULATA, MARRAM GRASS, IN THE INDIANA DUNES

LAING, CHARLES CORBETT

A simplified but generally acceptable concept of the population dynamics of marram is this: On aggrading dunes, vegetative culms are large, flowering culms are common and population densities are high. On stabilized dunes, vegetative culms are small, flowering culms are rare and population densities are low. Each of these measures of performance decreases with increasing age of a stabilized dune. The age of a stabilized dune is defined as the elapsed time since the surface was stabilized. It has been suggested that clonal age, the time elapsed since the seedling stage, is positively related to stabilized dune age. It has also been suggested that marram shows clonal senescence, a decline in performance with increasing clonal age. These hypotheses together are sufficient to explain the observed inverse relation between stabilized dune age and the performance of marram. However, the available evidence supports neither hypothesis.

If clonal age is to be positively related to stabilized dune age, seedling establishment must be the primary means of invasion on aggrading dunes and vegetative reproduction must be the primary means of population maitenance on stabilized dunes. In fact, though seedlings do establish on aggrading dunes, very few survive. Invasion by rhizomes and wave dispersal of vegetative fragments from existing clones are the usual means of invasion into aggrading dunes and into beaches. Hence, there is no reason to believe that there is any significant relation between stabilized dune age and clonal age.

In 1954, I collected vegetative material and grains from eroding fore dunes in Indiana. Using structural features, I estimated the age of this clone to be not less than fifteen years. The size, longevity and age-specific reproduction of the clone were estimated for these fifteen years. Clonal populations of the vegetative material and from the grains have been maitained since 1954. There has been no significant decline in the performance of either clone with increasing age. Neither has there been any significant difference in the performance of the old clone and the young clone derived from its grains. In 1966, this clonal material was transplanted onto an aggrading dune. The sizes, longevity and age-specific reproduction of the transplants were comparable to those of the culms collected in 1954. Direct studies, therefore, do not confirm the existance of clonal senescence in clones less than forty years of age. In the Indiana region, forty years is sufficient time for marram to be replaced on a stabilized dune or for it to become rare and debilitated. Clonal senescence has not been confirmed as a factor in the population dynamics of marram.

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DEMOGRAPHY OF SALIX SETCHELLIANA - A PROSTRATE WILLOW OF ALASKAN GRAVEL BARS

DOUGLAS, DOROTHY

This research concerns a prostrate willow (Salix setchelliana) which inhabits gravel bars of river bottoms in the Alaska Range. Field work is being done in Mt. McKinley National Park; the second of four years of the study has been completed. The purpose is to understand the population dynamics of the species and the relative importance of sexual and vegetative reproduction; reproductive allocation and demographic techniques are being used.

Populations in two river systems are being examined. On each river, both recently disturbed and less recently disturbed populations are included. Seventy-two square meter study plots have been located by a random coordinate method, and marked off by reinforced bar.

Demographic analysis involves a yearly mapping of all study plots. A wooden quadrat frame strung with string at one decimeter intervals allows for exact identification of shoots. This permits estimation of the demographic parameters of birth and death. Sexual reproduction on a per plant basis is also being quantified with this technique. Progressive excavations (through four years) of the study plots will hopefully confirm the demographic information obtained from mapping, describe population age structure, and determine the relative importance of vegetative and sexual reproduction.

Two years of field work have produced evidence indicating substantial turn over of shoots within populations. Excavations have located individuals of both sexual and vegetative origin, with vegetative being dominant, though catkin production is remarkably high.

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THE SAGUARO GIANT CACTUS: AN UPDATED ECOLOGICAL PERSPECTIVE

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Differences in growth rates, density, size and age structure of saguaro populations growing in dissimilar climatic environments and topographic habitats provide useful insights into the natural dynamics of the species. This investigation provides, for the first time, comparative information on growth and age relationships and related population parameters for saguaros growing in three differing climatic environments that are characteristic of a major portion of the species distribution in Arizona and northern Sonora, Mexico.

Relationships between climatic factors, growth rates, habitat suitability, and the structure and dynamics of saguaro populations are discussed. The question of stable-age distribution in populations of long-lived terrestrial species growing in non-equable climates of mid-latitudes is examined.

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TERRESTRIAL BIOLOGY: ZOOLOGY

TOWARDS AN UNDERSTANDING OF SPECIES CHANGES IN ISOLATED WILDLIFE COMMUNITIES

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An increasing number of experimental and observational research studies confirm the importance of island biogeographic theory for predicting characteristics of species communities on oceanic islands. Theoretical considerations and some empirical evidence are presented to support the contention that similar factors significantly influence the size and composition of communities in islands of natural habitat on continents. Observed community differences between continental sample areas and habitat islands are reviewed.

Two approaches are proposed for investigating and predicting future changes in recently isolated communities. A synecological approach involves studying the parameters influencing species distribution and abundance in isolated communities. The predictive significance of taxon density for understanding species-area phenomena is demonstrated. An autecological approach is presented to analyze population level problems associated with isolation in previously contiguous species communities. These problems are decomposed into a more analyzable hierarchy of population level phenomena. The influence of changes in population genetics, demography and resource availability on future alterations in the species community is considered. These methods of analysis can promote a greater understanding of the isolation process and of conservationists ability to predict and mitigate future changes in species presence and abundance in increasingly isolated National Parks and Wildlife Preserves.

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WATER LEVELS AND ALLIGATOR NESTING IN THE EVERGLADES

KUSHLAN, JAMES A. AND MARILYN S. KUSHLAN

The American Alligator (Alligator mississippiensis) is the dominant animal of the Everglades, shaping plant communities and affecting animal populations such as fish and wading birds. Water management installations north of Everglades National Park have altered surface discharge and affected hydrologic conditions in the park. Understanding the effect of water conditions on the Everglades alligator population is essential for providing better management of regulated surface discharge.

The study was conducted in the southern Everglades from 1975 through 1978. Various years of the study differed in water conditions, 1976 and 1978 being wetter than average and 1975 and 1977 being drier than average during the alligator nesting season. Preliminary relationships of nesting biology to water levels can be derived by comparing nesting parameters among these years. In general, the number of nests is greater in wet years, and average clutch size is smaller. Since smaller animals have smaller clutches, this suggests more younger animals nest in wet years. In wet years, alligators place eggs higher above the marsh bottom than in dry years, thus possibly decreasing the chance of flooding. These relationships suggest that nesting alligators can respond directly to water conditions at the time of nesting.

Discharge into the park in wet years depends on water conditions in shallow reservoirs to the north. When water levels exceed predetermined schedules, the excess is released into the park as flood discharge. In 1978, high water levels aggravated by flood discharge resulted in an estimated 40% loss of alligator eggs. Since the height of alligator eggs depends on water conditions, water management procedures should not result in unnatural water level rises after eggs are deposited. Revision of current water management procedures must take into account effects on other components of the Everglades system in order to preserve natural processes. Continued research on critical system components including alligators, fish, wading birds and hydrology is aimed towards establishing more natural water management in Everglades National Park.

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LAND MOLLUSCS ON THE CHANNEL ISLANDS NATIONAL MONUMENT

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Eight species of land snails are endemic to the islands in the Channel Islands National Monument, California. Santa Barbara Island supports the greatest diversity (6 species) followed by West Anacapa Island (3 species) and then East Anacapa, Middle Anacapa, and San Miguel Islands (all with 2 species). An additional species of introduced land slug has been reported on West Anacapa Island. During 1978 and 1979 the relative abundances, distributions, prefered habitats, and taxonomic standings of these snails was evaluated. Where available additional information was gathered to document life histories, feeding habits, activity patterns, mortality, and other elements critical to understanding the biology of these native land molluscs. The status of each snail was determined and measures essential to their protection were recommended.

The range of all snail species has been limited on all islands either directly or indirectly through habitat reduction or alteration or through the introduction of exotic animals. The foraging activities of feral animals, the farming activities of man, and the establishment of weedy plants have dramatically altered vegetation patterns. The Black Rat introduced on Anacapa and San Miguel Islands is a known predator on land snails. The Cochineal Scale Insect introduced as a biological control for the Prickly Pear Cactus has effectively destroyed a principal habitat for several snails on Anacapa Island. And ants introduced on all 3 islands competitively excludes snails from under rock habitats. Snails whose populations were deemed sensitive to the above impacts were catagorized as rare, threatened, or endangered depending on the nature of the threat and the degree of their vulnerability. Five of the 6 snail species on Santa Barbara Island and 2 of the 3 species on the Anacapa Islands have been recommended for protective status.

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ECOLOGY OF GORGONIANS (OCTOCORALLIA: GORGONACEA) AT DRY TORTUGAS, FLORIDA

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This study was conducted at Fort Jefferson National Monument during summer 1975, 1976, and was sponsored by the National Park Service. Species composition, distribution, diversity, and affinity of the gorgonian fauna of Long Key Reef is summarized. Thirteen transects, each 25 m long and roughly parallel to depth contours, were sampled. Transect numbers corresponded to meter number on a main traverse from 0.5 (m 360) to 21.3 (m 0) meters depth. Twenty-three species (598 included colonies) were recorded from transects. Thirty-five species were represented when additional 1 m^2 quadrats, incidental samples, and observations were included.

Shallow reef (0.5-9.1 m) gorgonian fauna was dominated by Plexaura flexuosa, Pseudopterogorgia americana, and P. bipinnata. A distinct gorgonian zone, composed primarily of 12 species (aforementioned, plus Eunicea mammosa, E. tourneforti, E. calyculata, Plexaura homomalla, Muricea atlantica, Pseudoplexaura flagellosa, P. porosa, Pseudopterogorgia acerosa, and Gorgonia ventalina), was evident between 3.0-9.1 m depth.

Deeper reef (9.1-21.3 m) sessile benthic fauna was dominated by scleractinians. Briareum asbestinum (scleraxonian gorgonian) was deleted from analyses because numbers of colonies were impossible to discern; with B. asbestinum omitted, P. bipinnata was dominant. Other gorgonians were G. ventalina, P. flexuosa, P. homomalla, and P. americana.

Highest Shannon-Weiner diversity value was for transect 220 (4.69-6.1 m). Diversity values decreased for transects in depths less than 3.0 m. Algae were the dominant sessile benthic biota of the reef crest. Gorgonian diversity values were also low for deeper reef transects due to P. bipinnata dominance.

Morisita faunal similarity values were highest for transects 220 and 170. Comparison of other shallow transects also yielded high similarity values, particularly for adjacent transects. High similarity values were also obtained by comparisons between deeper water transects. When deeper water transects were compared with transect 100 (8.8-9.4 m), low similarity values were obtained. Transects 130 (7.3-7.9 m) and 100 were highly dissimilar. Zonational transition from gorgonian to scleractinian dominance occurred between these transects.

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CALCIUM CARBONATE DEPOSITION IN REEF BUILDING CORALS

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Deposition of calcium carbonate by marine organisms is a widespread phenomenon, being especially evident in tropical waters where large biologically and geologically complex structures, coral reefs, develop. Numerous environmental factors influence the rate of deposition of calcium carbonate by corals but the most important one is light, which by influencing the rate of photosynthesis of the symbiotic algae in the coral tissue can cause up to a ten fold increase in the rate of deposition over the rate in the dark. The rate of growth of individual coral species obviously affects the rate of construction of the entire reef. An understanding of past and present reef growth can be obtained by relating information from the ^{14}C dating of cores to the more direct measures of coral growth.

The current study focuses on measuring the rate of linear extension and the rate of calcium carbonate deposition in the two major reef building coral species in Buck Island Reef National Monument, St. Croix, U.S. Virgin Islands. Acropora palmata is the dominant coral on the shallow windward reefs (0-5 m) in the Monument, comprising over 90% of the coral coverage in this zone. Acropora cervicornis forms dense stands on the shelf seaward of the base of the reef, and is a dominant species in deeper water (> 8 m). A year long study of A. palmata showed that most of the calcium carbonate deposited in shallow forereef colonies was due to an increase in the thickness of the arms, rather than apical extension (10 kg/m^2/yr vs. 0.3 kg/m^2/yr). Arms growing in shallower water had greater thickness and less linear extension relative to those growing in deeper water. The mean reef growth rate determined from these values (0.7 cm/yr) is comparable in magnitude to maximum known reef growth rates. Experiments are in progress to determine the extent to which monthly changes in linear extension and calcium carbonate deposition in A. cervicornis are correlated with the environmental variables of light, temperature and plankton availability.

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ECOLOGY OF A HIGH-ELEVATION ECTOTHERM: THE MOUNTAIN YELLOW-LEGGED FROG (Rana muscosa)

BRADFORD, DAVID F.

The Mountain Yellow-legged Frog (Rana muscosa) occurs at higher elevation than any other amphibian or reptile in the United States, ranging to over 3650 m elevation (12,000 feet) in the Sierra Nevada of California. The annual cycle of this conspicuous cold-dwelling species is characterized by 8-9 months of hibernation in ice-covered lakes and streams, with 3-4 months of activity during the cool summer. Like all amphibians and reptiles, R. muscosa is ectothermic, i.e. its body temperature is determined primarily by its environment. As an ectothermic vertebrate living in a cold environment, three factors are prominent in determining its ecological relationships and its distributional limits: (1) food availability; (2) environmental temperature and heat flux, and (3) duration of hibernation.

To understand the interaction of these factors, I am currently investigating the ecology of R. muscosa in several populations in Sequoia and Kings Canyon National Parks, CA. In each population, environmental temperatures and food abundance are monitored continuously. Population dynamics, reproduction, growth, diet, and fat content are followed in both tadpoles and frogs. The thermoregulatory behavior of frogs and tadpoles, and the formation of dense aggregations by adult frogs, are being examined in conjunction with measurements of the physical environment.

During some winters, many of these alpine frog populations are totally destroyed, whereas the tadpole populations survive. Two possible causes of this winter die-off are being examined: (1) oxygen depletion in ice-covered lakes and (2) starvation. Dissolved oxygen is being monitored in several lakes during winter. Laboratory experiments with hibernating tadpoles and frogs are being conducted to determine the minimum oxygen concentrations that can be tolerated during hibernation and the total energy required for hibernation.

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POND SUCCESSION AND CANNIBALISM: TIGER SALAMANDER POPULATIONS ON THE NORTH RIM OF GRAND CANYON NATIONAL PARK

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Seral stages of natural, sinkhole ponds include open water with no emergent, aquatic vegetation through the shoreline emergent sere to the pond choaked with burweed throughout. All ponds support larval populations of tiger salamanders (Ambystoma tigrinum), but only the youngest support cannibalism of large, broad-headed morphs upon their smaller, typical siblings. Only the earliest ponds exhibit P/R values usually greater than 1, and these support larval populations of at least $4.8/m^2$. Presumably high plankton production leads to dense invertebrate populations that foster dense tiger salamander larvae, in turn supporting the cannibalistic habit. Advantages of cannibalism are transformation with a larger, more robust body that is more mobile and resistant to desiccation, hence more successful in the overland journey to the terrestrial burrow typical of adults.

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POPULATION STRUCTURE AND ECOLOGY OF THE FOWLER'S TOAD, BUFO WOODHOUSEI FOWLERI, IN THE INDIANA DUNES NATIONAL LAKESHORE

BREDEN, FELIX

A long-term study has been initiated on the population dynamics of the Fowler's Toad, Bufo woodhousei fowleri, in the Indiana Dunes National Lakeshore. The sizes and productivities of the breeding populations, and the dispersal patterns of the toads will be quantified. The main goal will be to relate these parameters to the population genetic structure. Also, this population ecology data, especially the large observed variance in reproductive output between ecologically similar ponds, could be important to amphibian resource management.

The West Beach Area study site consists of seven interdunal areas, each containing one to three ponds Adult toads are individually marked by a system of toe-clipping and freeze-branding. Data from the springs and summers of 1978 and 1979 yield estimates of total population size, fidelity to breeding ponds and migration between ponds, and dispersal to summer quarters. These summer quarters often involve "beach frequenting" behavior along the Lake Michigan shore. Over 5,000 metamorphic and juvenile toads have been marked in Spring, 1979, with per-pond marks in an attempt to monitor dispersal from natal ponds to the ponds where these toads will breed. This method of marking yields estimates of metamorhpic output that show order of magnitude differences between ecologically similar ponds.

Adult toads are bled for acrylamide electrophoresis of blood proteins, and the toes used for marking are saved and analysed for seven starch electrophoretic loci. A comparison of the toads within the West Beach Area of the Park and Fowler's toad populations in the entire range of the species showsthat the Park population is monomorphic at several loci that are generally polymorphic in the species. This genetic homozygosity may be related to the island nature of this population, caused by the residential use of near-by habitat.

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A DETAILED CHEMICAL RECORD OF THE PLANTS AND INSECTS IN THE BAT ECOSYSTEM IS PRESERVED IN THE CAVES NEAR CARLSBAD, NEW MEXICO

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Chemical measurements of hydrocarbons in bat guano indicate that biologists could eventually determine both the species of insects eaten by the bats and also the plant communities which sustained the insects themselves. Given the extensive guano deposits in the Carlsbad region, a vast chemical record of bat paleoecology, spanning thousands of years, awaits our interpretation.

Because insects synthesize a characteristic array of high molecular weight branched-chain alkanes, our discovery of a similar array of alkanes in Carlsbad bat guano indicates that these compounds derived from the insects eaten by the bats. These compounds resisted destruction both in the bats and in the several thousand years of burial in the guano deposit. Carbon isotopic measurements were performed upon the individual normal and branched hydrocarbons. It has been shown that insects usually produce in abundance only one or two high molecular weight branched hydrocarbon compounds. Many groups of these hydrocarbons can be found in the guano, each group having a constant carbon-13 abundance. Such "clusters" of compounds probably derive from distinctive species or groups of species of insects. If the hydrocarbons found in all the insect species in the Carlsbad region were determined, it would be possible to list which insect species constituted the diet of the Carlsbad area bats.

The Carlsbad bats feed in the Pecos River valley to the east. Carbon isotopic analyses of the 55 most abundant plant species in the valley produced a pattern markedly similar to the isotopic pattern found in the guano hydrocarbons. Since past work shows that the stable carbon isotopic composition of insects reflects the isotopic composition of their food source, the carbon isotopic composition of the hydrocarbons in the guano reflect the plants eaten by the insects. Some hydrocarbons are depleted in carbon-13 relative to others, indicating that some insects consumed C3 type plants, which are commonly represented in this area by shrubs and trees. Most of the hydrocarbons are enriched in carbon-13, indicating the substantial consumption of C4 type plants, notably grasses and succulents. It appears that the insects, and therefore the bats, are supported by the grasses of the Pecos River Valley.

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THE LAND BIRDS OF LITUYA BAY: OLD HABITATS IN A NEW LAND

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Certain avian habitats located in the vicinity of Lituya Bay in Glacier Bay National Monument, Alaska have persisted undisturbed since at least the neoglacial ice receded from the region. These old forested habitats account for over half of the 47 terrestrial bird species and 56% of all individuals recorded on 5 study transects. Fewer species were recorded from the more ephemeral habitats. Calculated faunal resemblances among the 10 identified habitats showed greater commonality among the old growth forest habitats than each exhibited with the other avian habitats. Conversely, about one third of the birds recorded appear widespread among the habitats, while the remaining species are largely restricted to a few habitats where the critical resources are present. Some of these latter species may be marginal with an existence that is erratic or problematic depending upon sudden local environmental changes. Three families of passerine birds demonstrated diverse habitat differences within and between major groups. Niche characteristics were estimated for these selected taxa. Consequently, the differences in niche characterization can be used to estimate changes occurring through ecological succession or those induced by human activities.

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AVIAN COMMUNITY RELATIONSHIPS AT THE BUFFALO NATIONAL RIVER IN ARKANSAS

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Bird species occurrences in the various vegetational habitats at the Buffalo National River in the Arkansan Ozarks were determined both in winter and during the summer nesting season. There were no striking overall trends in changing avifaunal richness between the two seasons, although there were big differences in some communities in this regard. Gower's principal co-ordinates analysis was employed to show relative similarities between avain communities. The resulting ordination sorted the various communities on environmental axes and also separated the winter and summer avifaunas. The scatter of summer communities was greater than the winter ones, indicating less widespread occurrences of bird species in different habitats in summer than in winter.

Nine habitat types were surveyed for the presence of bird species from January through March in 1979 and in May, June and July in 1978. Avifaunal richness varied from a low of 4 species in cedar glade habitat in winter to 51 species in mixed lowland forest in the nesting season. The other habitats represented were; gravel bar, floodplain forest, oak-hickory upland forest, oak-pine forest, beech forest, field and pasture.

The advantages of employing Gower's principal co-ordinates ordination was demonstrated with respect to several sets of biogeographical data in the literature. The validity of this approach also was exhibited with respect to the present avian ecological data. The resulting ordination of avian communities at the Buffalo National River not only showed the degree of relationships between communities but also documented ecological trends and categories. A related Gower's analysis of bird species distribution across habitats indicated ecological affinities among bird species.

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SOCIAL STRUCTURE IN A SOOTY TERN COLONY

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The Sooty Tern Sterna fuscata is a pantropical seabird represented in NPS areas by a colony of about 45,000 pairs at Fort Jefferson National Monument, Florida, in which about 40 percent of the adults are banded. Data from banded birds show that the population is characterized by: low average annual adult mortality (12 percent, as a first estimate); extended immaturity (few breed before age 7); an aged breeding population (mean age of 466 breeders in 1979, 13.72 years; range, 5-23+); and, extreme longevity (maximum known age, 32 years). Here we report initial findings on mating patterns, nest site fidelity, entry of new breeders into the population, and social organization based on 352 adults trapped on nests and individually color-banded in 1972-1979. Work centered on a 9 m^2 plot where an average of 36 pairs nested.

Mating - Of 229 former breeders returning to breed 26 percent paired again with a previous mate, 34 percent paired with other birds although former mates were present and breeding, and 40 percent paired with other birds in the absence of former mates. Birds that did not maintain pair-bonds tended strongly to mate with birds that had occupied contiguous or nearby (within 1 m) territories in a previous year. The mating pattern seems adapted to snychronization of breeding and to the fact that many established breeders apparently do not attempt to nest every year. Pairs tend to be of similar age and either sex may be the older. Site Relations - Mean movement of the nest sites of individuals in successive breeding attempts was 2.6 m. Pairs that remained together in successive seasons moved significantly less, 1.2 m. New Breeders - To enter the tightly structured breeding population an individual must first secure and hold standing space in the colony, usually late in the season when territoriality of established breeders is relaxed. Both sexes stand, they do so at similar ages, and they may stand at the same place in several seasons. On limited data it appears that the successful standers ultimately nest within 1 m of their standing spot. Colony Structure - Our observations suggest that the colony is made of relatively discrete "neighborhoods" determined by nest site tenacity and group adherence. A neighborhood seems to occupy an area of roughly 50 m^2 and involves several hundred individuals known to one another from previous social interactions.

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ECOLOGY AND DISTRIBUTION OF BIRDS WITH EMPHASIS ON COLUMBIDAE IN THE NORTHERN U. S. VIRGIN ISLANDS

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During the last century changes in the insular avian composition of the Virgin Islands were infrequently recorded. The goal of this study, based at the Virgin Islands Ecological Research Station within the National Park, St. John, was to evaluate the status of resident birds, especially Columbidae, in relation to faunal colonizations, both natural and human-directed. A knowledge of 1) differences between native species' breeding behavior, in habitat use, and distribution, 2) factors in the immigration and extinction equilibrium, and 3) turnover rate, can contribute to preserving unique insular species.

A study of resident columbid species and habitat use from December, 1977 to April, 1978 provided some additional information on resource overlap and the distribution of two congeners: the locally endangered White-crowned Pigeon (Columba leucocephala) and the Scaly-naped Pigeon (C. squamosa). Further discussion is offered on the probabilities of other endangered congeners coexisting on islands of the Puerto Rican Bank.

Several species have not been reported during the last fifty years in some of the northern Virgin Islands, presumably due to the changing aspect of habitats since plantation farming and the introduction of the mongoose (Herpestes auropunctatus). In some instances the use of these tropical habitats has increased from a variety of migrants as well as West Indian species immigrating to the islands. If the balance of immigrations and extinctions is equal, successful colonizations portend losses which would significantly alter the equilibrium ratio for small islands in the Antilles.

Management for a particular species or habitat may become increasingly necessary in the future as human requirments force difficult decisions. These factors are considered in relation to the National Park, St. John, and the Virgin Islands as refugia for unique insular fauna.

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NUMBERS, MORPHOLOGY, AND MOVEMENT PATTERNS OF BALD EAGLES AT AUTUMN CONCENTRATIONS IN GLACIER NATIONAL PARK, MONTANA

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Migrating bald eagles (Haliaeetus leucocephalus alascanus) congregate along lower McDonald Creek, Glacier National Park, Montana, during the autumn to feed on kokanee salmon (Oncorhynchus nerka kennerlyi), a species introduced into the drainage in about 1916. In the autumns of 1977 and 1978 we conducted weekly censuses of bald eagles. Maximum counts from a canoe, along 4 km of creek, were 444 (30 November 1977) and 618 (29 November 1978). In 2 years (1977 and 1978), 30 eagles (28 subadults and 2 adults) were captured. Morphology of each eagle was characterized by a series of 22 measurements. Patagial markers were placed on both wings and a standard leg band was affixed to one leg. Sightings of marked eagles have been reported from near Creston, Montana; in British Columbia, along the North Fork of the Flathead River, 15 miles north of the U.S. boundary; and near Burns, Oregon. Three major night roost areas within Glacier Park were identified.

Eagles were captured in double-spring leg traps (No. 3) with heavily padded jaws, placed under 10-15 cm of water in the creek, 30-40 cm from salmon bait stations. Traps were set before dawn and were under continuous observation when set. Traps were set on 35 days during the 2 seasons, resulting in 1.2 trap-days per eagle. The mean weight of the 30 captured eagles was 4.95 kg (3.95-6.45 kg); mean wingspread was 204 cm (180-215 cm).

In the autumn of 1978, 3 of the 10 eagles that had been marked in 1977 were resighted along McDonald Creek. A subadult bald eagle marked in the San Luis Valley, Colorado, in March 1977 was observed along McDonald Creek for 7 weeks in 1978. In 1977 we used yellow patagials, as assigned by the Bird Banding Laboratory. Our color assignment in 1978 was changed to bright orange. In addition to marking, we will tail mount transmitters on several eagles and track their local and long-range movements during and after the 1979 concentration. Knowledge of movement patterns is essential for the preparation of regional and national management plans for the bald eagle.

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IMPORTANCE OF THE COLORADO RIVER IN GRAND CANYON NATIONAL PARK AS A CORRIDOR FOR MIGRATORY PASSERIFORMES

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The importance of the availability of riparian habitat for migrant passerine stopover feeding and resting areas may be only one facet of the overall importance of river corridors to some species of migratory passeriform birds. Contiguous, uninterrupted tracts of riparian habitat along natural river corridors with a general north-south orientation through arid lands or unpreferred habitats may be important to certain migratory Passeriformes, a factor usually overlooked in management decisions regarding riverine or riparian habitat alterations. Passerines which appear to utilize the corridor of the Colorado River through the Grand Canyon region primarily or exclusively during migration have been identified.

A portion (18%) of the total migrant passeriform birds recorded for the Grand Canyon region of Northern Arizona utilize the corridor of the Colorado River primarily or exclusively during migration. These may be identified as migratory-corridor-preferential species for the region. This may be related to topographic features and/or specific stopover habitat preferences, species' regional movement patterns, and the location of the study area relative to the total range of a species. Four passerine species were found to utilize the river corridor exclusively during migration. These four species have only recently expanded their range to now include the Grand Canyon region, with the Grand Canyon presently at the northern periphery of their range. The riparian corridor of the Colorado River exists as a likely avenue for such range extensions.

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RESPONSE OF BREEDING BIRD POPULATIONS TO FIRE IN BIG SAGEBRUSH-PONDEROSA PINE TRANSITION COMMUNITY

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Breeding bird territories were mapped on 20 hectare grids in burned and unburned ponderosa pine-big sagebrush transition communities in Lava Beds National Monument, California, in the spring and summer of 1979. One grid was located in an area that was burned by wildfire in the summer of 1973 and another was located in an area that was prescribed burned in 1977. Unburned control grids were located adjacent to each burned grid. Prior to burning, all areas had scattered ponderosa pine and western juniper, but mountain mahogany, antelope bitterbrush and big sagebrush dominated the vegetation.

The wildfire grid showed significantly less avian diversity compared to it's control grid. The area swept by the 1973 wildfire showed little vegetative variety both vertically and horizontally. Only one small island of vegetation survived the wildfire; the rest of the area was dominated by bunchgrasses. Consequently, avian diversity was lower in the burned area than in the control grid where the vegetation structure was more varied. Ground nesting birds dominated the burn area, especially western meadowlarks and rock wrens. The control area had a variety of shrub and tree nesting birds.

The prescribed burn grid showed significantly greater avian diversity compared to it's control grid. The area burned by prescription in 1977 showed the greater vegetative variety and therefore breeding bird diversity. The burned area had an interspersion of burned and unburned areas; therefore, much "edge" and nesting habitat. The area had a wide range of ground, shrub, and tree nesting birds, while the unburned area had almost no ground nesting birds and fewer shrub and tree nesting birds.

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RED FOX PREDATION ON BREEDING GULLS AT SOUTH MANITOU ISLAND, SLEEPING BEAR DUNES NATIONAL LAKESHORE

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The impact of Red Fox predation on gull reproductive success and colony stability has been monitored since 1975. Each year, except 1977, fox activity in the Ring-billed and Herring Gull colonies resulted in nearly complete reproductive failure for both gull species. During this period, the number of breeding pairs of Ring-billed Gulls in the colony has decreased to about 25% of those present in 1975. The Herring Gull colony also exhibited fluctuations in population size but this species' response to fox predation and reproductive failure is decidedly different from that witnessed by Ring-billed Gulls. The impact of foxes during each stage of the nesting cycle was monitored. In addition, other potentially limiting factors were evaluated as to their possible contribution to gull losses.

The situation on South Manitou does not fit the typical predator-prey model familiar to most people. Foxes, in this case, apparently are not dependent upon gulls as an energy source. Their population is sustained by other types of food during the absence of gulls (August to March) and to a large extent even when gulls are present. In spite of this, the foxes requently raid the gull colonies and the aftermath of their activities is best described as "surplus killing." It is unlikely that a balance will ever be reached in this situation wherein foxes and gulls will coexist on the island. Instead, continued fox predation is expected to cause the gulls to abandon the colony sites. The time required for this to occur is longer than predicted on the basis of published accounts and apparently will differ for each of the two species.

Although the literature refers to antipredator behavior being performed by gulls, there is little evidence to document that Herring Gulls or Ring-billed Gulls possess effective adaptations for reducing the impact of nocturnal mammalian predators that gain access to colonies. The gulls appear dependent upon the availability of isolated nesting sites that are free of predators. When this barrier breaks down, as in the case of South Manitou, the gulls and their progeny are completely vulnerable to predation.

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NUMERICAL RESPONSE OF WOODPECKERS AND THEIR EFFECTS ON MOUNTAIN PINE BEETLES IN LODGEPOLE PINE IN NORTHWESTERN MONTANA

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Five species of woodpeckers and their relationship to and impact on an epidemic population of mountain pine beetles (Dendroctonus ponderosae) were studied in lodgepole pine (Pinus contorta v. latifolia) forests of northwestern Glacier National Park from March 1978 through September 1979. The beetles have spread over 140,000 acres of lodgepole in the Park since the early 1970's causing substantial tree mortality and providing an abundance of food for woodpeckers. Pileated (Dryocopus pileatus), northern three-toed (Picoides tridactylus), black-backed three-toed (P. arcticus), hairy (P. villosus), and downy (P. pubescens) woodpeckers feed on the beetles year-round. Estimates of woodpecker and beetle densities and woodpecker-caused mortality of beetles were made on 8 plots. Twenty-two active nests were located and described.

Seven study plots were located in the Park in beetle-infested lodgepole which varied in stand age and density and occurred on sites differing in general topography. One control plot was located in the Flathead National Forest in lodgepole with an endemic beetle population. Woodpeckers were censused year-round on variable-width-strip plots approximately 0.5 miles long. Woodpecker densities as high as 49 birds per 100 acres in the winter and 13 birds per 100 acres in the breeding season were observed on the epidemic plots; no woodpeckers were observed on the endemic plot. Densities of beetle-infested lodgepole were as high as 280 trees per acre on the epidemic plots; on the endemic plot only one unsuccessfully attacked lodgepole was found. Bark samples were collected every 2-4 weeks to estimate beetle densities and natural mortality. Woodpecker-caused mortality was calculated by estimating the amount of bark disturbed by feeding woodpeckers. Preliminary estimates indicate maximum densities of about 20,000 larvae per tree. Winter temperatures of -40 F. increased susceptibility of the 1978 beetle brood to natural mortality factors resulting in significantly decreased survivorship.

Northern three-toed woodpeckers were the most common species; 11 nests were located, 7 in beetle-killed lodgepole, 2 in lodgepole snags, and 2 in live aspen. Six hairy nests were found, 5 in live birch or aspen, and only one in beetle-killed lodgepole. Downy, black-backed three-toed, and pileated woodpecker nests were also found on the plots.

Although the superabundance of food appears to account for the high densities of woodpeckers throughout the study area, the availability of suitable nest and roost sites appears to limit the number of breeding woodpeckers on specific plots.

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MANAGEMENT OF SEABIRD RESOURCES IN THE CHANNEL ISLANDS NATIONAL MONUMENT

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The vast majority of marine birds breeding in southern California nest on islands under the jurisdiction of the Channel Islands National Monument. During the nesting season, these birds forage in water near their colonies. When not nesting, some bird populations leave the southern California Bight, while others remain close to the islands where they nest.

During the breeding season, seabird colonies are potentially vulnerable to disturbance. Throughout the year, and particularly in the nesting season, seabirds are sensitive to fluctuations in the availability of their preferred prey. These sensitivities to disturbance and prey availability must be the focus of management efforts. The Park Service is able to control access to colonies and thus keep potential disturbance of nesting birds within acceptable limits. However, the waters where the birds forage are managed by a combination of Federal and State agencies, and the Park Service has had little impact on management policies. It is critical for the health of organisms within the Monument dependent on marine resources that effective interagency programs for resource management be developed.

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THE INVESTIGATION OF AVIAN MALARIA IN HAWAII'S NATIONAL PARKS

van RIPER, CHARLES III

Early and recent ornithological workers in Hawaii have implied that the extirpation of the native Hawaiian avifauna has come about as a result of the birds' susceptibility to introduced diseases. However, no study to date has conclusively shown this to be true. The primary thrust of this work was to determine the impact of introduced avian malaria upon the native avifauna of Hawaii's National Parks.

Five basic questions were asked in this study:

1. How many species of malaria are present in Hawaii?
2. How susceptible are Hawaiian birds to introduced malarial parasites?
3. What is the overall percentage of birds affected today, and is there any temporal variance in parasite levels within host groups?
4. How is the malarial parasite transmitted to birds within Hawaii's National Parks?
5. What management steps need to be taken by National Park Service Managers to protect their avian resources?

The results obtained on each of these five questions will be discussed, showing that:

1. Only one species of avian malaria is believed to be present in Hawaii's National Parks.
2. Some of the native bird species tend to be more susceptible to introduced diseases than do others.
3. There is a temporal as well as elevational difference in levels of infection in the birds.
4. Malaria is transmitted primarily by the introduced night-biting mosquito Culex quinquefasciatus.
5. With the elimination of unnecessary standing water and introduced avian and mammalian species, park resource managers can better protect their avian resources.

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FOOD HABITS OF THE ISLAND FOX ON SAN MIGUEL ISLAND

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The food habits of the Island Fox (Urocyon littoralis littoralis) were studied on San Miguel Island during 1978 and 1979. These foxes were found to be omnivorous and, for the most part, opportunistic in their feeding habits. They consume a wide variety of plants and animals. Deer Mice (Peromyscus maniculatus), insects (grasshoppers, crickets, beetles, and lepidopteran larva) and the fruits of iceplants were the most important components of their diet.

During this study, 208 scats, grouped into four seasonal samples, were analyzed. The summer and fall samples were found to be comprised of insects and the fruits of iceplant while the winter and spring samples were comprised of Deer Mice, birds, insects and iceplant.

Fruit from the Sea Fig, a native iceplant (Carpobrotus aequilaterus), was found in 96 percent of the summer scats analyzed and comprised 88 percent of the volume of these scats. Vegetation other than iceplant made up a relatively minor portion of the foxes' total diet. Birds were most abundant in the spring sample (22 percent occurrence). This coincides with the nesting season of the ground nesting birds. Birds, however, only constitute a minor proportion of the overall diet of these foxes. Lizards were only found as trace occurrences and were not a significant item of the foxes' diet. Deer Mice were most important to the foxes during the winter season (53 percent volume). Grasshoppers, crickets, and allies (Orthoptera) were the predominant insect group consumed with Jerusalem Crickets being a staple throughout the year. Jerusalem Crickets were most abundant in the spring and winter samples (occurring in 72 to 80 percent of the scats). The Devastating Grasshopper (Melanoplus devastator) was most important in the fall sample. Beetles (Coleoptera) were common in the spring sample with only minor occurrences during the remainder of the year. Butterfly and moth larvae (Lepidoptera) were more common in the spring and fall samples and absent from the summer sample. Both Coleoptera and Lepidoptera did not constitute a significant portion of the foxes' overall diet.

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RESPONSES OF A DEATH VALLEY RODENT POPULATION TO VARIABLE FOOD SUPPLIES AND CLIMATIC EXTREMES

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A population of small mammals in northern Death Valley was live-trapped to determine its responses to extremes in food supplies and climate. Long-tailed pocket mice, *Perognathus formosus*, were the most numerous species. They remained active during the summer heat by restricting their activities to after sunset, but they had to enter prolonged periods of torpor to survive winter weather. Pocket mice adapted to years of low food supplies by ceasing growth and reproduction. Adequate food supplies insured reproduction, after which most adults died and the population consisted of subadults. Seven other species of rodents displayed different strategies to cope with environmental stresses.

A total of 21,388 trap-nights of effort were expended capturing 9,503 rodents. Although eight species were trapped, pocket mice and Merriam's kangaroo rat, *Dipodomys merriami*, accounted for 95% of the captures. *Perognathus* were torpid an average of 2 to 4 months during the winter. Pre-breeding season populations ranged between 40 and 120 animals on the 2.7 hectare study area. If breeding occurred peak summer populations were between 130 and 230 animals. When food supplies and other conditions were poor no breeding occurred and summer populations steadily declined. Estimated home range sizes for both sexes were 0.2 ha except in years when breeding occurred: then males' ranges averaged 0.5 ha.

Between 1975 and 1979 winter annuals germinated and flowered only in 1976 and 1978. The dominant heteromyid rodents did not show an unequivocal relationship between reproductive success and production of winter annuals as had been reported elsewhere. Kangaroo rats bred successfully every year but 1977: pocket mice reproduced in 1976 and 1978, years with winter annuals, but they also bred in 1979, a year totally devoid of winter annuals.

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BISON-PRAIRIE DOG-PLANT INTERACTIONS AT WIND CAVE NATIONAL PARK, SOUTH DAKOTA

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Studies are being conducted to test the hypothesis that North American bison (*Bison bison*) make heavy mid-late season use of prairie dog (*Cynomys ludovicianus*) towns because of higher food quality there than on off-town sites. To examine this problem, we are (1) collecting data on seasonal changes in habitat use by bison in the park, (2) calculating activity budgets for bull and cow groups while on the prairie dog towns, and (3) determining the influence of prairie dogs on food quantity and quality, including crude protein content and in vitro dry matter digestibility.

Although prairie dog towns occupy only 4% of the total park area, 53% of the total bison observations in August, 1978 were on such towns. The dominant activity recorded for bison on prairie dog towns was grazing, and it accounted for 47% of their total observed time. Total plant biomass on dog towns at this time ranged from 123-164 $g \cdot m^{-2}$, while values from off-town control sites ranged from 225-320 $g \cdot m^{-2}$. Western wheatgrass (*Agropyron smithii*), the dominant grass on the prairie dog towns, was chosen for intensive study in 1978. Biomass of *A. smithii* was from 11-35 $g \cdot m^{-2}$ on four different dog towns, and from 24-39 $g \cdot m^{-2}$ on similar soil types from control sites. Both percent crude protein and in vitro dry matter digestibility were significantly greater in *A. smithii* plants from dog towns than off-dog town sites. Crude protein in plants from two dog towns was 10.2% and 10.3%, while it was 8.8% and 8.3% in plants from paired control areas. Values for in vitro dry matter digestibility were 51.6% and 56.5% for plants from the two dog towns, and 45.6% and 50.6% for plants from the two control areas, respectively.

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INFLUENCE OF FOOD SUPPLY ON COYOTE POPULATIONS IN JACKSON HOLE, WYOMING

WEAVER, JOHN

The influence of food supply upon coyotes (*Canis latrans*) in three areas of Jackson Hole, Wyoming, was investigated 1973-1975. Northern pocket gophers (*Thomomys talpoides*), Uinta ground squirrels (*Spermophilus armatus*), and field voles (*Microtus* spp.) were the principal foods in the May-October diet of coyotes. They fed primarily upon ungulate carrion during winter. Deer mice (*Peromyscus maniculatus*) and chipmunks (*Eutamias* spp.) comprised most of the rodent biomass captured in traps in the fall whereas ground squirrels accounted for much of the rodent biomass in spring. The abundance and availability of both summer and winter foods varied substantially between areas and between years. Up to six-fold differences in coyote population indices occurred between areas and were attributed primarily to differences in the amount of ungulate carrion available during winter. Possible influences of nutrition upon coyote natality, mortality, and movements are contemplated.

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NUTRITIONAL QUALITY OF ELK SUMMER DIETS IN ROCKY MOUNTAIN NATIONAL PARK

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Nutritional quality of elk summer diets was studied in relation to advancing season and plant community types on alpine and subalpine summer range in Rocky Mountain National Park during July-September of 1977 and 1978. Diet quality was not affected by location of feeding. We observed significant declines in diet quality as summer progressed and significant differences between years.

Crude protein and in vitro digestible drymatter (IVDDM) content of elk diets consumed on alpine tundra, krumholtz ecotone, and subalpine parkland were estimated each month based on analysis of forage samples and estimation of diet botanical composition. Bite counts of forage choices of 3 tame elk in combination with handplucked bite weight estimates were used to estimate the dryweight species composition of elk diets.

There were no differences in dietary crude protein ($P=.11$) or IVDDM ($P=.09$) among vegetation types. Both measures were significantly lower the second year than the first ($P=.001$). During year 1, IVDDM in diets declined significantly ($P=.001$) from a mean (across animals and communities) of 54% during July to 43% in September. The second year, diet IVDDM did not decline over the same time interval (year x month interaction, $P=.001$). Crude protein in diets declined linearly ($P=.001$) over summer during year 1 from 17% to 10% and from 15% to 10% the following year. There were no differences in dietary crude protein content among animals ($P=.62$); however, we did observe differences in their diet IVDDM values ($P=.004$).

Based on these data and on studies of nutritional requirements of wild and domestic ruminants, we infer that elk diets from summer range in Rocky Mountain National Park provide digestible energy and protein in substantial excess of maintenance requirements. From a nutritional standpoint, elk appear to be able to obtain high quality diets in a variety of habitat types. We conclude that animal condition at the end of summer is probably variable from year to year.

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NUTRITIONAL EVALUATION OF ELK WINTER HABITAT IN ROCKY MOUNTAIN NATIONAL PARK

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The upper montane zone in Rocky Mountain National Park contains a diverse mosaic of plant communities used by elk for feeding during winter. We address the question: "Are there differences in the nutritional quality of elk diets among upper montane plant communities?" We conclude that quality of elk diets is not predictably dependent on feeding location.

Elk diet quality was investigated in grassland, sagebrush, ponderosa pine, willow, aspen, and wet, mesic, and shrub meadow vegetation types during November-March of 1976-77 and 1977-78. Bite counts of forage choices of 5 tame elk and hand-plucked "bite" samples were used to estimate dry weight botanical composition of elk diets. Forage samples of major species in elk diets were analyzed for crude protein, and *in vitro* digestible dry matter (IVDDM). Diet protein and IVDDM content were estimated as the sum of forage quality values weighted by their diet proportions.

During both years, dietary IVDDM values were highest in aspen, and protein content of diets was consistently high in willow but usually low in mesic meadow. However, ranking habitat types according to nutritional quality of diets selected was not possible for two reasons. First, we observed a significant ($P < 0.05$) year-x-habitat interaction for diet protein and IVDDM. That is, because annual changes in diet quality were not proportional across habitats, Year 1 ranking of habitats by diet quality differed from that of Year 2. Second, the differences in diet quality among habitats within years were small. During both years diets in all habitats contained close to 5% protein, dietary IVDDM ranged from 40% to 47% during Year 1 and from 34% to 39% during Year 2.

We infer from these data that elk can make efficient use of a wide variety of upper montane habitats.

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MAMMAL DISTRIBUTION AND NATURAL DISTURBANCE IN A NORTH CASCADES GLACIAL CANYON

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The distribution of 31 mammal species in the recently deglaciated Nooksack Canyon corresponded to the form and frequency of natural disturbances. Analysis of plant communities within the canyon and cirque indicated that succession and hence community structure varies with type, duration, and frequency of disturbance. Snap trapping data from each plant community showed a comparable pattern in small mammal distributions. In plant communities characterized by frequent, catastrophic disturbances (e.g. avalanche chutes) only generalist mammal species, such as deer mice and certain shrews were found. Among deer mice sampled, individuals tended to be larger in size, sex ratios were skewed in favor of males, and few juveniles were present in the frequently disturbed sites. Conversely, in plant communities with long term disturbance cycles (e.g. western hemlock forests) mammal species were not necessarily generalists, individuals were not large, sex ratios were normal, and juveniles were present. The effects of planned human disturbance on mammal populations thus may be evaluated both through potential impacts on plant community dynamics and possible shifts in mammal population characteristics.

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THE MAMMALS OF BIG THICKET NATIONAL PRESERVE

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Big Thicket National Preserve (BTNP) is situated within a four county area of the Big Thicket in East Texas. The design of the preserve itself is unusual in that it does not encompass a single, extensive, continuous area but rather is made up of eight disjunct representative units, varying in size from 500 to 25,000 acres, and four corridor units distributed along the waterways in the region.

From May 1977 to May 1979 we surveyed the mammalian fauna of BTNP under a research contract with the National Park Service. The major emphases of the study were directed towards the collection of small mammals and bats, and the censusing of game and fur-bearing mammals. A total of 1110 specimens were collected, including 923 small terrestrial mammals, 111 bats, 31 fossorial mammals, and 45 miscellaneous mammals. Time-area counts were conducted to census squirrels; track counts were used to estimate deer frequencies. All findings were analyzed in conjunction with 12 previously defined habitat types.

Our field work and survey of the literature indicate that 52 species of mammals have occurred in the area now occupied by BTNP during historic times. Of the 52 species, one is a marsupial, three are insectivores, eight bats, one edentate, two lagomorphs, 16 rodents, 18 carnivores, and three artiodactyls. Included in the 52 species are two introduced rodents (Mus musculus and Myocastor coypus) and three domestic species (Canis domesticus, Felis catus, and Sus scrofa) which occur in the wild often enough to be regarded as feral. Of the 52 species known from the preserve, eight should be considered extirpated from the area. One native species (Castor canadensis) has been extirpated but has been replaced in recent years by restocking. Most, if not all, of these species have disappeared as the direct result of human activity.

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ESTIMATING SMALL MAMMAL POPULATIONS AT THE BUFFALO NATIONAL RIVER IN ARKANSAS

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Estimates of animal population levels that are based on the familiar capture-mark-recapture type studies are questionable, because certain assumptions, inherent in the chosen mathematical model, often cannot be met in practice. Review of the literature leading to the development of the Schnabel method (a multiple census variation of the Lincoln Index) shows that a major assumption is that the population being censused remains constant over the sampling period. However, typically in live-trapping experiments there is a known population fluctuation due to trap mortality or intentional removal of specimens. Overton's iterative extension to this model has been used to account for the known removal of individuals, but we used a new iterative process to replace this, which simplifies the computation of the adjustment for population fluctuation.

The results of four separate small mammal population studies in which this new modification was employed are reported. The studies were conducted in old field habitats in the fall of 1978, at the Buffalo National River in Arkansas. Combined species population estimates are 8150, 1555, 427, and 1630 individual small mammals per 40 hectares for the four study sites, which were represented by 2, 3, 6, and 4 species respectively. Individual species population levels are reported as percentages of the combined species estimates, which in most cases were highly dependant on data from the dominant species in each field. Confidence limits were determined for the total rodent population estimates. Three of the rodent species exhibited different microhabitat selection along a gradient of old field succession.

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REOCCUPATION BY BEAVER AND THE OTTER NICHE IN GREAT SMOKY MOUNTAINS NATIONAL PARK

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Beaver (Castor canadensis) were extirpated from Great Smoky Mountains National Park (GRSM) by the time of its creation in 1934, and otter (Lutra lutra) were extirpated soon afterward. In recent years beaver have been extending their ranges in all five adjacent states, and in 1968 they reentered the Park at Eagle Creek. Information on beaver range, habitat, and food habits is presented, along with the potential otter niche.

Beaver presently occupy six drainages in the Park and are invading at an average rate of 4.0 km of stream per year. Beaver are largely confined to the lower 2 - 5 km of slower moving water near the Park boundary, although foraging extends as far as 14 km into the Park.

Gradient is high in the Park streams and few beaver dams are built. Twenty-one species of trees and shrubs were fed upon in the five streams studied. A value index based upon relative abundance and degree of utilization indicated flowering dogwood (Cornus florida) was by far the most important species. Yellow poplar (Liriodendron tulipfera), black birch (Betula lenta), yellow birch (Betula lutea), oaks (Quercus spp.), sycamore (Plantanus occidentalis), ironwood (Carpinus caroliniana), beech (Fagus grandifolia), witch hazel (Hamamelis virginiana), hemlock (Tsuga canadensis), and alder (Alnus serrulata) all had a value index over 50. We predicted that the best otter habitat would also be in the pools and slower moving water near the Park boundary and consequently would be a somewhat limited range. Fish population changes have been considerable since the 1930's as exotic brown trout (Salmo trutta) and rainbow trout (Salmo gairdeneri) progressively invade the Park.

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POPULATION STUDIES OF BLACK BEARS IN GREAT SMOKY MOUNTAINS NATIONAL PARK

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Since 1972 over 300 black bears have been trapped, tagged, and released in the Great Smoky Mountains National Park. Population estimates indicate a density of bears in the Park at 400 to 600 and stable. Fluctuations in numbers occur due to the influence of mast availability which in turn affects both productivity and vulnerability of bears to hunting activities. Population pressures in the form of dominant, aggressive males apparently result in dispersal of younger animals. Poor mast years (1 in 5) result in lowered productivity and dramatic shifts in spring-summer home ranges to completely different fall ranges; however, most bears return to their spring-summer ranges to den. Bears accommodate seasonal changes in availability of foods, primarily soft and hard mast, by altering their movements and activity patterns. Annual home ranges average 15 km^2 for adult females and 40 km^2 for adult males. Average age of adult males is over 2 years younger than the average for adult females reflecting the greater mobility and consequent vulnerability of males to mortality. The combined effects of sex, reproductive status, photoperiod, weather, and food availability result in entrance into winter dens varying between 15 November and 15 January. Most bears select dens high above ground (7-30 meters) in cavities of large trees; the selective advantage of such sites provides a critical component for the survival of bears in the southern appalachian mountains.

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MINIMUM VIABLE POPULATION SIZES FOR THE GRIZZLY BEAR

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The problems of defining and determining minimum viable population sizes and their area requirements are considered first. Four components of random extinction are recognized, namely: demographic, environmental, and genetic stochasticity, and natural catastrophes. A minimum viable population for any given species in any given habitat is tentatively defined as the smallest population having a 95% chance of remaining extant for 100 years despite the forseeable effects of the four components of random extinction.

Review of available information on the grizzly bear reveals substantial variation (both geographic and temporal) in life history phenomena and population characteristics. However, there is little information on the relative contribution of various environmental factors or genetic characteristics in producing such variation. Natural catastrophes are apparently of little importance to the species.

A discrete, stochastic simulation is developed for testing the relationship of population size and survival in variable environments. Using the data available for the Yellowstone grizzlies, a population of about 50 bears satisfies the above definition of a minimum viable population with respect to environmental and demographic stochasticity. Lack of information precludes testing the effects of genetic stochasticity or natural catastrophes. The above estimate is fairly stable to departures in the parameter values and relationships used in the simulation. Factors most likely to affect the estimate are simultaneous errors in the mean values of mortality rate, percent of females reproducing, and average litter sizes; the cub sex ratio; and the age of first reproduction in females.

The estimate of minimum viable population size derived from the data on the Yellowstone grizzlies will likely vary for other populations. Nevertheless, using the above estimate as a first approximation with data on the average density of the species in other areas yields estimates of minimum area requirements ranging from 1050 km^2 (northern Rockies) to 7400 km^2 (Brooks Range). Comparison of these estimates with areas currently designated as critical habitat for the grizzly indicates that one area (Kaniksu) may be marginally small.

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CHRONIC FLUORIDE TOXICOSIS IN YELLOWSTONE NATIONAL PARK

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Distinctive tooth and bone lesions characteristic of chronic fluoride toxicosis have been found in deer, elk, and buffalo from Yellowstone National Park. Sources of excessive fluoride include water from geothermal features of the park, and some vegetation that has been immersed in the waters of high fluoride content. Fluoride analyses of water samples collected in the park ranged from a fraction of a part per million (ppm) F in some rivers, to near 30 ppm F in some geothermal waters. Limited vegetative F analyses ranged from under 10 ppm F to as high as 430 ppm F on a dry weight basis. No contamination from industrial pollution has been incriminated in these cases. Lesions seen in the animals can be related with analytical data on fluoride content of selected water and vegetation samples.

Major lesions caused by excessive ingested fluorides occur in developing permanent teeth and bones. Fluorides are avid seekers of calcifying tissues. Bones may be adversely affected throughout an animal's lifetime, but the teeth are adversely affected only during the period of their formation and calcification. If dental lesions are severe enough, accelerated wear occurs with use and excessive wear may occur as the animal ages. Fluoride induced dental lesions may be classified numerically from 0 (normal) to 5 (severe) changes.

In both wild and domestic animals, osteofluorotic lesions are most often located on the proximal medial aspect of the metatarsal bones, and on the ribs and mandible. Other bones are also affected, however. The gross palpable bones changes are preceded by distinctive radiographic and microscopic changes.

Only trace amounts of fluoride are located in soft tissues of the body. No lesions specifically attributable to excessive fluorides have been found in any soft tissues or organs.

Eleven factors including: amount and solubility of F ingested, duration of ingestion, animal species and age, ingestion fluctuations, overall nutrition, physiological stresses, general health, and individual biologic response all influence the expression of fluoride toxicosis in animals.

The wild animals studied from YNP have shown lesions similar to wild animals from other areas and domestic animals in their expression of chronic fluoride toxicosis.

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POTENTIAL DEMOGRAPHIC CONSEQUENCES OF TRANSPLANTS OF DESERT BIGHORN SHEEP[1]

LESLIE, DAVID M., JR.[2]

Computer simulations were used to examine possible demographic consequences of removal of desert bighorn sheep (Ovis canadensis nelsoni) from an established population and to examine population growth of transplanted groups of sheep of various age and sex compositions. A discrete model with 22 variables was employed and was designed to mimic the annual cycle of natality and mortality of desert bighorn sheep. Basic assumptions that underpinned the model were derived primarily from empirical observations of the subspecies in the River Mountains of Lake Mead National Recreation Area, Nevada. Because specific data on certain aspects of survival and fecundity of desert bighorn sheep were lacking, information from literature on Rocky Mountain bighorn sheep (O. c. canadensis) and domestic sheep (O. aires) was used. Fifty-one, 20-year simulations have been conducted to date. Generally, results of those simulations indicated that 1) removal of old sheep from an established population had the least impact and 2) a transplant comprised of young to middle-aged ewes was likely to meet with the greatest success. That dicotomy can be reconciled by removal and transplantation of a group with females selected from all age classes. Superficially, results further suggested that a strategy of sustainable yield could be applied to populations of desert bighorn sheep. Unfortunately, those results did not account for year-to-year fluctuations in habitat quality, which may render lamb survival completely density-independent. Given unpredictability in the food base of these large, desert herbivores, response of an established population to removal of individuals and growth of a transplanted group cannot be viewed within the realm of classic density-dependent idioms.

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MOTHER-INFANT INTERACTIONS AMONG FREE-RANGING, NON-NATIVE MOUNTAIN GOATS (OREAMNOS AMERICANUS) IN OLYMPIC NATIONAL PARK, WASHINGTON

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Studies of mother-infant interactions among a large population of free-ranging, non-native Rocky Mountain goats (Oreamnos americanus) were conducted as part of a 2 year, on-going investigation of mountain goat social biology in the Olympic National Park, Washington. Since Park Administrators have allowed extensive marking of individual animals in connection with a complementary study of population biology and habitat utilization, it was possible to closely observe recognizable mother-infant pairs and to quantify the frequency and type of interactions occurring among them. Descriptions of observed behavioral interactions between mothers and offspring are presented, as well as quantitative data on the frequency and rate of their occurence. Data are also presented on the maintenance of mother-infant proximity and the relationship between maternal activity patterns and offspring behavior. Some preliminary data are presented on cases in which mothers retained yearling and 2 year old offspring and continued to exhibit considerable tolerance and some maternal care. The results are discussed with respect to current theoretical issues and compared to previous studies of mother-infant relationships in ungulates.

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INTRODUCTION AND DISPERSAL OF MOUNTAIN GOATS IN OLYMPIC NATIONAL PARK, WASHINGTON

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Although native to the Cascade Mountains of central Washington State, the mountain goat, Oreamnos americanus, was introduced to the Olympic Mountains of northwestern Washington by humans prior to creation of Olympic National Park. There is no historical evidence of goats in the Olympic Mountains before the release of 12 to 15 animals from Canada and Alaska between 1925 and 1929.

Dispersal of this new population is traced during the past 50 years from release sites near what is presently the north boundary of the Park. Moving east and south at a rate of about 5 km per year, the population apparently reached a maximum dispersal of 80 km, at the southern edge of the mountains, about 1960. It is presently distributed throughout the Olympic Mountains in an area totaling about 1,800 km^2. Ninety percent of the available habitat is in the Park.

A local irruption since 1970 to over 200 goats on Mount Angeles, 16 km from the original release sites, has prompted special concern by Park managers about controlling the population and reducing habitat changes that are apparent. Intensive research on the alteration of native ecosystems by goats and their population dynamics is underway to assist in developing an appropriate management program.

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NUMBERS OF MOOSE AT ISLE ROYALE

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For the past 15 years we have been estimating the number of moose (Alces alces) on Isle Royale by means of winter-time counts from an aircraft and post-winter counts of fecal pellets. Results have afforded insights on population trends, and they have served to calibrate census techniques. In the face of intense predation by wolves, the Park's moose have remained at levels higher than previously estimated. The population has been fluctuating, but far less dramatically than during the pre-wolf decades of the 1920's and 30's.

The authors made aerial counts from 1964 to 1970; thereafter Peterson (1978), using our sampling procedure, has continued this inventory. We have made pellet counts nearly every year since 1964.

Except for 1964, aerial surveys involved intensive coverage of small plots by means of overlapping flight circles from a small fixed-wing aircraft. Total area sampled averaged 11 percent of the 550-km^2 island. Starting in 1966, sampling intensity was stratified according to moose density at the time of the counts. On one occasion, efficiency of counting from fixed-wing craft was evaluated by parallel counting from a rotor-wing craft. The fixed-wing counts were 12% less complete; furthermore, even with intense searching from the helicopter, moose were missed.

Between 1963 and 1979, winter pellets groups were counted in spring on permanently marked, 66-m^2 plots arranged into 43 lines of 10-20 each and distributed in all regions and major habitat types of the island. A total of 550 plots, comprising 0.0066% of the land surface, has been established, but in no one year were all plots visited. Using aerial-count results plus calculations of forage consumption and digestion, we estimated that winter defecation rate is 19.5 groups/day.

Best estimates of annual pre-parturition, minimum population levels for the years 1964-70 were obtained from a combination of aerial and pellet-count results. Estimates ranged from around 800 in 1964 to over 1500 in 1967 with an average of around 1200. Post-1970 pellet counts suggest a population peak occurred around 1972 after which numbers declined, corroborating aerial counts by Peterson during this period.

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EFFECT OF ELK ON VEGETATION IN ROCKY MOUNTAIN NATIONAL PARK

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In 1968, a management decision was made to allow the elk population within Rocky Mountain National Park to increase toward ecological carrying capacity and equilibrium with its forage supply. The only population control buffering this increase was to be public hunting outside the Park boundaries. A total of 54 vegetation transects were established in 1968 and 1969 to document the response of various vegetation types to the impact of elk. Areas of study included low elevation and alpine winter range and subalpine summer range. In 1973 and again in 1978, the transects were remeasured to demonstrate changes in composition and cover as the result of ungulate use.

Summarizing results for the overall low elevation indicates some significant changes. Seral vegetation types--aspen and willow--showed the most change. In three of the four aspen stands monitored, mature trees declined. Willow cover declined in five of the six plots. On upland sites, bare ground increased, bitterbrush (Purshia tridentata) increased, and big sagebrush (Artemisia tridentata) decreased. Most species on these sites, however, showed no significant changes, and generally the sites indicated stable conditions. Except for willow areas, the high elevation sites are also stable.

Monitoring of these study areas will continue to obtain information on which to base management actions.

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AUTHOR INDEX

NOTE: The number following the author's name refers to the *page number* on which the abstract may be found.

A

Abell, Dana L., 61
Ahler, Stanley A., 12
Ahlstrand, Gary M., 278
Albee, T. F., 130
Alexander, John F., Jr., 236
Aley, Thomas, 159
Allen, Harriet, 395
Allred, Linda, 354
Anderson, Adrienne B., 23
Arundale, Wendy H., 46

B

Baccus, John T., 322
Bacone, John A., 112
Baker, D. L., 406, 407
Baker, Gail A., 283, 284
Baker, James K., 264
Baker, Suzanne, 30
Bane, Carol A., 54
Banko, Paul C., 222, 223
Banko, Winston E., 223
Barber, Larry B., II, 354
Barker, J. R., 306
Barnette, Brian, 409
Baron, Jill, 248
Bass, Oron L., Jr., 216
Baumgartner, Roland, 104, 204
Becker, R. H., 187, 198
Benedict, Mark A., 319, 365
Benedict, Nathan B., 122
Bennett, Peter, 114, 250
Bentley, Frederick W., 154
Berelson, William M., 141
Bergthold, Patricia M., 349
Berry, J. A., 372
Bickel, Polly McW., 4
Bisson, P. A., 209
Blumenthal, Lisa, 364
Bluth, Karen, 364
Blyth, Amélie, 321
Bonnicksen, Thomas M., 273
Botti, Stephen, 271
Bowers, Janice E., 111, 118
Bradford, David F., 387
Bradford, Wesley L., 164
Bradley, William, 329
Bradshaw, Richard L., 37
Bratton, Susan, 229, 244, 304, 308, 311
Breden, Felix, 389
Brickler, Stanley, 161
Briscoe, B. W., 338
Brodhead, John, 317
Brown, Bryan T., 355, 396
Brown, Kenneth W., 126, 129
Brown, Laurie, 162
Brown, Robert Thorson, 119
Buckley, Francine G., 217
Buckley, Paul A., 217
Bunin, Jane, 101
Burch, William R., Jr., 180
Burge, Raymond E., 109, 261, 321
Burke, William J., 37
Burnham, William, 218
Burns, S., 104
Butterfield, Katherine A., 114, 355

C

Calabrese, F. A., 11
Caldwell, John, 362
Call, C. A., 306
Campbell, Ronald K., 112
Carbyn, L. N., 338
Carlson, J. E., 323
Carothers, Steven W., 66, 67, 250, 262
Carpenter, Scott L., 18
Chandler, Susan M., 31

Chaney, Rufus L., 85
Chase, D. D., 348
Cheek, Neil H., Jr., 184
Chilman, K. C., 194, 197
Chubb, Michael, 193
Clark, Elizabeth, 354
Clarke, Joann, 364
Cline, David, 373
Coffman, Michael S., 276
Colburn, Elizabeth A., 56
Cole, Glen F., 333
Coleman, Stuart, 242
Collins, Paul W., 402
Conant, Sheila, 224
Coppock, D. L., 404
Cornely, John E., 342
Cotera, Augustus, 373
Crystal, Joseph H., 173
Cummins, Kenneth W., 208
Cutter, Susan L., 178

D

Davies, Kenneth, 95
Davis, Gary E., 336
Davis, Russell C., 86, 88
Davis, Stephen, 140, 363
Dawson, Richard H., 337
DeBenedetti, Steven H., 290
DeBusk, William, 258, 370
Deck, John R., 33, 34, 35
Dennis, John G., 251, 252
Des Marais, David J., 151, 390
Detling, J. K., 404
Diamont, Rolf, 330
Diem, Kenneth L., 65
Ditton, Robert B., 196
Dodd, J. L., 404
Douglas, Charles L., 340
Douglas, Dorothy, 378
Dow, V., 104
Drabick, Lawrence W., 200
Dragavon, John A., 408
Drager, Dwight L., 6
Driver, Chas. H., 329
Duchelle, Steve, 131
Duek, J. Lee, 302
Duever, M. J., 323
Dullea, Mark, 76
Dunn, James E., 410
Dyer, M. I., 404

E

Eagar, Jane T., 185
Ebert, James I., 5
Effland, Richard W., 31
Ehrenhard, Ellen B., 10
Ehrenhard, John E., 9
Eleuterius, Lionel, 362
Ellis, J. E., 407
Ely, Jennifer F., 80
Engel, Ronald J., 181
Enrico, Joseph, 91
Estes, R. Don, 68
Euler, Robert C., 31
Evans, John O., 265
Ewel, John, 258, 370

F

Fanale, Rosalie, 7
Fanter, Lloyd W., 341
Farley, Mike, 321
Fedler, Anthony G., 196
Feldman, H., 353
Fenn, Dennis B., 33, 34, 35, 36
Ferris, James, 276
Field, Donald R., 184
Fleet, Harvey, 357
Fleming, Peggy, 89
Foggin, G. Thomas, III, 59
Forbes, Mark E., 165
Ford, John I., 226
Foss, J. E., 84
Foster, David I., 159, 194
Foust, Richard D., 162, 373
Foxx, Teralene S., 296
Franklin, Jerry F., 206, 210, 212
Fries, Nancy L., 332

G

Gardner, Donald E., 261
Garrow, Holly Crandall, 142
Gates, W. A., 187, 198
Gay, Bonnielou, 90, 91
Gehlbach, Frederick R., 388
Geiger, N. Stan, 60
Giesler, Deborah, 364
Gilbert, Barrie K., 343
Gilbert, Richard, 175
Gladfelter, Elizabeth H., 386
Godfrey, Melinda, 364

Godfrey, Paul J., 317, 318, 319, 364, 365
Goodman, Richard E., 156
Goodwin, R. G., 147, 348
Gordon, Bruce R., 374
Graefe, Alan R., 196
Grauman, Melody Webb, 45
Greenberg, Russel, 288
Greenlee, Jason, 288
Greenwood, Roberta S., 32
Gregg, William, 330
Gustke, Larry, 191
Gutierrez, Alberto A., 5

H

Haight, Lois T., 331
Hamilton, Wayne L., 154
Hammerschlag, Richard S., 79
Hamor, Susan, 373
Hansen, Craig, 416
Hansen, Katherine, 104, 376
Hansen, Susan K., 43, 48
Hardy, Mark A., 167
Hargis, Jack R., 55
Harmon, Mark, 244, 277, 285
Harvey, Michael J., 221
Hastings, Bruce C., 343
Hauer, Richard, 58
Hauxwell, Donald L., 374
Hawks, Graham, 354
Hearon, Suzanne S., 78
Hemstrom, Miles A., 275
Hendrickson, William H., 169, 334
Henslick, John, 237
Herndon, Alan, 293
Heron, S. Duncan, Jr., 141
Herriman, Walter P., 33, 134
Hobbs, N. T., 406, 407
Hochberg, F. G., 384
Hochberg, M. C., 115, 260
Hoesterey, John W., 190
Holland, James S., 233
Hoppe, Steven, 162, 373
Hornick, Sharon B., 83, 85
Horton, Jack K., 322
Huff, Mark H., 243, 282
Hunt, George L., Jr., 400
Hunter, Shonah, 354
Hurst, Clyde J., 265
Hutchins, Michael, 416

I

Ingmanson, John Earl, 39
Ives, J. D., 104
Iwatsubo, Rick T., 164

J

Jacob, Gerald R., 189
Jacobi, James D., 247
Jacobs, D. F., 360
James, Douglas, 392, 410
Janke, Robert A., 371
Jenkins, Kurt J., 213
Johnson, Arlen H., 294
Johnson, Donald Lee, 152
Johnson, R. Roy, 100, 111, 250, 331, 349, 355, 396
Jones, A. Trinkle, 31
Jones, Bruce A., 19
Jones, Steve L., 341
Jordan, James W., 66, 67, 262
Jordan, Peter A., 418
Junak, S. A., 115, 260
June, J. A., 209

K

Kaeding, Lynn R., 64
Karnosky, D. F., 73
Kaya, Calvin M., 64
Keiper, Ronald R., 254, 255
Keller, E., 145
Kelly, Roger E., 52
Ketchin, Anne-Forrest, 3, 104
Ketz, James A., 41
Kiefer, W. E., 353
Kingston, Newton, 65
Kinzie, Robert A., III, 226
Kittleson, Barbara C., 393
Kliene, Marvin, 135
Klubnikin, Kheryn, 369
Knight, Dennis H., 287
Knopf, Richard C., 172
Kostka, Stanley J., 77
Kraushaar, James, 176, 358
Krekler, C. H., 353
Kress, Lance W., 131
Kucma, Gail A., 178
Kurmis, Villis, 116
Kushlan, James A., 383
Kushlan, Marilyn S., 383

L

Labrode, David, 411
Laing, Charles Corbett, 377
Lambert, Robin Lee, 211
Lange, D. D., 73
LaRoi, George, 210
Larson, Bruce C., 286
Larson, Douglas W., 60, 165
Larson, Gary, 69, 70, 128, 130, 163
Laven, Richard D., 270
Leatherman, Stephen P., 316, 318, 320, 330
Leiker, Karen K., 202
Lemons, John, 300
Leslie, David M., Jr., 415
Lester, Amy, 399
Libbey, David, 47, 49
Lichvar, Robert, 232
Lienkaemper, George W., 207
Lind, Owen T., 54
Lockerd, M. Joseph, 354, 392, 410
Lockerd, Rose, 354
Loftus, William, 216
Loope, Lloyd L., 110, 123
Lowe, Charles H., 379
Lowe, James, 399
Luff, David, 104, 352
Lynott, Mark J., 20
Lyons, Thomas R., 6

M

MacDonald, A., 145
Machlis, Gary E., 180
MacLeod, Susan A., 301
Major, Jack, 122
Malm, William C., 135, 202
Marceau, Thomas E., 27
Marcotte, James R., 44
Marnell, L. F., 194
Martin, Robert E., 272, 294, 397
Mastrogiuseppe, Joy D., 375
Mastrogiuseppe, Ronald J., 295, 375
Mathews, Raymond, Jr., 109, 128, 163, 308
Mayberry, Jim, 52
McArthur, Katherine L., 186
McBride, J. R., 360
McClelland, B. Riley, 59, 395, 399
McCord, B., 104
McCrone, John D., 346
McDaniel, Pattie, 373
McGraw, Donald J., 94
McHugh, Brian, 134
McIlwain, Jerry P., 230
McKee, Arthur, 210
McKell, C. M., 306
McKenzie, G. D., 147, 348
McManamon, Francis P., 22
Medlock, Linda M., 47
Meents, Julie K., 351
Merikangas, Jacqueline B., 231
Merriam, L. C., 116
Meyer, Paul W., 74
Meyer, William, 166
Middleton, Beth, 307
Milestone, James F., 310
Miller, Julia M. G., 149
Miller, Ronald I., 382
Minckley, C. O., 66, 67, 262
Mitchum, Douglas, 65
Moir, William H., 101, 279, 351
Molenar, John V., 202
Moore, Garland, 134
Moore, Stephen, 69
Moorhead, Bruce B., 417
Moran, M. Susan, 355
Morehead, John M., 339
Morgan, D. L., 138
Mortensen, B. Kim, 105, 302
Moss, Mary Beth, 254
Mouat, David A., 100, 105
Murov, Marilyn, 162
Murphy, Mark A., 253
Murray, Jack J., 83

N

Nichols, Rosemary, 312
Nichols, Tom, 271
Nickel, Robert, 13
Niemann, B. J., 187, 198
Nigh, Timothy A., 354
Nordstrom, Karl F., 178
Norton, Robert L., 394
Nyquist, Maurice O., 107

O

O'Dell, Kenneth, 135
O'Farrell, Joan T., 403
O'Farrell, Thomas P., 403
Ojima, Dennis, 258, 370
Okeefe, Timothy G., 347
Oliver, Chadwick Dearing, 286
Olkowski, Helga, 72
Olkowski, William, 72
Olmsted, Ingrid, 110
Olson, A. E., 414
Olson, Craig M., 272, 294, 397
Omi, Philip N., 269, 291
Osborn, Gerald, 148
Otvos, Ervin G., Jr., 143

P

Palmer, James F., 173, 201, 203, 316
Parker, Thomas C., 189
Parman, Terry P., 289
Parr, J. F., 81
Parsons, David J., 176, 274, 283, 284
Patterson, Gary, 216
Patterson, James C., 82, 83, 84, 85, 86
Paulissen, Mark, 354
Pedersen, Sverre, 49
Pelton, Michael R., 412
Petersen, Phillip, 265
Peterson, H. B., 414
Peterson, Larry C., 62
Peterson, Rolf O., 339
Philbrick, R. N., 115, 260
Phillips, Arthur M., III, 111, 114, 250
Phillips, Barbara G., 111, 114
Phillips, Jeannette H., 96, 97
Phillips, Ora Gail, 97
Pierotti, David, 373
Pittillo, J. Dan, 121, 228
Plam, M., 104
Post, Donald F., 36
Potter, Loren D., 296
Preston, Charles R., 392
Purcell, Alice, 292

Q

Quinlan, James F., 160

R

Rakestraw, L., 276
Ramsey, Eleanor Mason, 2
Randall, Lois C., 62
Rauw, Denison, 268
Redenbaugh, M. K., 73
Reeve, Stuart A., 28
Reichhardt, Karen L., 105
Reid, William H., 303
Reiten, Jon, 14
Rentz, Lee, 179, 192
Reshkin, Mark, 353
Rhoads, Ann F., 74
Richner, Jeffrey J., 21
Ridley, Bromfield, 69, 70
Riopelle, L. A., 323
Robertson, Mary J., 393
Robertson, William B., Jr., 393
Robbins, John C., 36
Robinson, William L., 341
Rogers, J. David, 146, 153, 155, 156
Roggenbuck, Joseph, 195
Rognstad, Ralph, Jr., 238
Rominger, James, 373
Romme, William H., 287
Rose, Paul W., 158
Rosendahl, Peter C., 157, 158
Rubel, Margo, 288
Ruffner, George A., 250
Rundel, Philip W., 283, 284
Runte, Alfred, 326

S

Sackett, Russell H., 50
Salzman, Sally S., 4
Saveland, Robert N., 98
Schechter, Howard R., 133
Schelberg, John D., 38
Schiebout, Judith A., 150
Schmidly, David J., 409
Schmidt, Thomas W., 63
Schneider, William, 49
Schnoes, Roger, 292
Schramm, Dennis R., 233
Schreiner, Edward, 298

Schreyer, Richard, 182, 192, 195
Scott, Linda J., 24
Sczawinski, Timothy, 42
Sedell, James R., 209, 212
Seemann, J. R., 372
Shabica, Charles, 144
Shabica, Stephen, 144, 227, 321, 362
Shaffer, Mark, 413
Shea, David, 395
Sheekey, Elizabeth, 288
Shelby, Bo, 177
Sheppard, William, 42
Sherald, James L., 75, 77, 78
Short, John R., 82, 84, 86
Shupe, J. L., 414
Siegel, Lou, 90
Sieger, Thomas L., 87
Sikora, L. J., 81
Silsbee, David, 109, 128, 163
Silverstein, Harold, 90
Singer, Francis, 242, 244, 245, 411
Skelly, John M., 131
Sleznick, James, Jr., 272
Slusser, W. F., 138
Smathers, Garrett A., 121, 368
Smith, Clifford W., 225, 289
Smith, Jack E., 40
Smith, Kimberly G., 392
Southern, William E., 398
Spalding, Albert G., 341
Spencer, Edward L., 80, 305, 359
Spicher, Douglas, 364
Sprague, Lorrie, 411
Stalter, Richard, 366
Stanford, Jack A., 58
Starkey, Edward, 213, 292
Stearn, Roger J., 305
Steenbergh, W. F., 379
Steiner, Alan J., 320
Stephens, N. Thomas, 130
Stevens, David R., 419
Stevens, Victoria, 417
Stevens, W. Frederick, 263
Stiger, Mark A., 25
Stohlgren, Thomas, 176
Stone, Edward C., 273
Stottlemyer, J. Robert, 108, 170
Streveler, G. S., 348
Stromberg, Linda, 311
Stromberg, Mark R., 232
Stutzman, Suzanne M., 356
Summer, Rebecca M., 299
Swaney, Dennis, 239
Swanson, Frederick J., 207, 212
Sweeney, Jeff, 70
Swift, D. W., 407

T

Tally, T., 145
Tanacredi, John T., 87, 95
Taylor, Dale L., 293
Thiessen, Thomas D., 16
Thomas, L. K., Jr., 220, 256, 257
Tiagwad, Tamara E., 397
Tilmant, James T., 313
Timbrook, S. L., 115, 260
Tipps, Betsy L., 29
Tipton, William M., 309
Tomrdle, Dale, 106, 179
Trimble, Michael K., 17
Trottier, G. C., 338
Tunnicliff, Brock M., 161

U

Usher, Howell D., 66, 67, 262

V

Valentine, Wayne, 321
Van Doren, Carlton, 191
Van Riper, Charles, III, 401
Van Wagtendonk, Jan W., 174
Veirs, Stephen D., Jr., 280
Villeponteaux, James, 288
Vincent, John R., 34
Vogler, Detlev R., 132

W

Waggoner, Gary S., 120
Wagner, Richard H., 367
Walters, Jim, 249
Walther, Eric, 135
Wampler, Kirk, 289
Ward, G. Milton, 208

Ware, John A., 51
Warren, Peter L., 105
Warshauer, Frederick R., 246
Watkins, Charles H., 88
Wauer, Roland H., 251, 328
Weaver, John, 405
Weaver, Thomas A., 350
Webb, Sara, 116
Weber, N. V., 353
Weisbrod, A. R., 263, 391, 408
Weishar, Lee, 139, 140
West, Neil E., 281
Wester, Horace V., 88
Westfall, R. D., 73
Weston, Timothy, 12
Westover, Theresa, 193
Wetmore, Clifford, 117
Weymouth, John W., 8
Wheaton, Jennifer, 385
Whelan, Q. Nicholas, 332
White, Elizabeth, 364
White, Leslie D., 340
White, Peter, 102, 219, 229, 244, 308
White, Robert G., 182
Whiteaker, Louis D., 103
Whittaker, Paul, 304
Wickstrom, Conrad E., 57
Wiegert, Richard G., 57
Wiersma, G. Bruce, 126, 129
Wilcox, Douglas A., 168, 169
Wilhelm, Gerould S., 112
Wilkening, Marvin, 137
Williams, Wayne T., 136
Willson, G. B., 81
Witzeman, Stewart, 373
Wolf, Donald W., 177
Wolfe, Michael L., 418
Wood, Gene W., 253
Wood, W. Raymond, 15, 16
Wood, William, 139, 140, 363
Woodhouse, Charles D., 113
Wright, Gary A., 26
Wright, R. Gerald, 335

Y

Yarborough, Keith A., 127, 134
Yoshinaga, Alvin Y., 259

Z

Zaremba, Robert E., 318
Zeitlin-Hale, Lynne, 335
Zervanos, Stamitis M., 254
Zube, Ervin, 173



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