PARK SCIENCE

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PARK SCIENCE

NATIONAL PARK SERVICE

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

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Cover: *Stream gauges established on Poore Creek, Petersburg National Battlefield, make possible a quantitative evaluation of storm runoff from the urbanized watershed (see story page 3).*

Meet the New AD

Dr. F. Eugene Hester has been appointed Associate Director for Natural Resources for the National Park Service. Before joining the Service, he was Deputy Director of the U.S. Fish and Wildlife Service (1981-1987). Hester began his career in 1959 as Assistant Professor of Zoology at North Carolina State University. In 1963, he left this position to become the leader of the North Carolina Cooperative Fishery Research Unit of the USFWS. He became Chief of the Division of Fishery Research in 1971 and later was made Associate Director for Research (1974-1981). Among the numerous awards Hester has received for his service with the Federal Government, are the Department of the Interior Meritorious Service Award (1981) and a Presidential Distinguished Rank Award (1982).

He has a B.S. from North Carolina State University, an M.S. in wildlife biology from North Carolina State, and a Ph.D. in fisheries from Auburn University. He has published widely on fish genetics, fisheries management, and waterfowl population dynamics. An accomplished wildlife photographer, he has had photos published in and on the cover of many magazines.

Of the many diverse natural resource issues in the NPS science sphere, Dr. Hester indicated particular interest in genetic and biological diversity, the implementation of a Servicewide strategy to collect baseline inventory and long-term monitoring information, and the ecological impacts of adjacent land use changes on resources in the parks. One of Dr. Hester's first activities will be to visit the Regions, meet with the Regional Directors, Regional natural resource management and science staffs, and park staffs, and discuss how the Washington Office can help them address natural resource management problems. He expressed particular interest in assuring that the necessary communications occur between managers and scientists so that management decisions will be based on good scientific information.

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How Urban Development Near Parks is Affecting Streams

By James D. Gregory, Charles A. Williams, Karl (Chuck) Smith, Chuck Rafkind, Sam Kunkle, and John Karish

Urban development closing in on small park units in densely populated areas can have severe ecological effects on park resources. One example is construction upstream from a park, which can cause erosion, flooding, siltation, and even vegetation die-off in a park. Preliminary observations indicate that Petersburg and Richmond National Battlefields, two NPS sites in central Virginia, are cases in point.

The Petersburg Study

At Petersburg National Battlefield (NB), extensive upstream construction of highways, housing and other developments evidently is causing excessive channel erosion along Poore Creek, a small stream flowing through the heart of the park (Fig. 1). Unusually high volumes of runoff in Poore Creek are now seen during storms. The increased runoff is undercutting the stream banks, causing large trees to uproot and fall into the stream, and has scoured out the channel to its clay base. This is a classic example of the runoff impacts caused by the conversion of forest and fields into asphalt and roofs. Such runoff water also may be of poor quality, which can adversely affect park resources and their use.

In order to stimulate interest in more effective upstream conservation, the park has initiated a study of Poore Creek's urbanization impacts and is working in cooperation with the Department of Forestry at North Carolina State University. The objective of the Petersburg NB study is to evaluate runoff from Poore Creek and its urbanized watershed of 1,230 acres to determine if the runoff from storms is in fact abnormally high and causing the severe channel erosion. In the study, two types of comparisons are being made. First, new runoff data from Poore Creek will be compared to available runoff models and existing case studies from the region. Secondly, runoff comparisons will be made using a control stream, Harrison Creek, which is also in the park and lies adjacent to the Poore Creek watershed. Harrison Creek drains an area of 1,179 acres that exhibits few urbanization impacts but otherwise is similar to the Poore Creek drainage.

Stream gauging and precipitation measuring sites have been established, and field measurements of runoff and water quality are underway (see cover). Park staff are surveying cross-sections along Poore Creek and Harrison Creeks so that long-term cross-sectional measurements can be repeated and erosion quantified with existing park resources beyond the research contract period. An automatic storm-water sampler, which fills up when a stream rises during storm events, is being assembled in the park so that sediment in storm runoff can be monitored. In order to evaluate pollution and erosion impacts, water samples are being collected for analysis of bacterial contamination, suspended sediment, and dissolved solids, and benthic macroinvertebrates are being surveyed in the stream.

Preliminary storm data collected to date at the stream gauging sites indicate that Poore Creek is drastically affected by the urbanization: storm runoff is much higher in Poore Creek than in the control stream. Sewage contamination also has been found. It is too early to pronounce findings on channel erosion, which must be measured over time.

The Richmond Study

At Richmond National Battlefield Park (NBP), urbanization is having a different impact on the riparian environment. Erosion from housing and road construction upstream apparently is sending increased sediment loads downstream into the park's Beaver Dam Creek Unit (Fig. 2). Loss of forest cover upstream also is very likely causing higher peak flows during storms. Because this park unit lies in a lowland area, it serves as a natural deposition site for sediment; preliminary observations at a grid of stakes driven into the ground already are showing that sediment is being deposited. Many of the hardwoods and other vegetation in the unit are showing signs of stress or die-off, apparently a result of the excessive sedimentation. Increased runoff and the sediment deposits also have altered an old mill race that is an important historic feature of the park. Because construction adjacent to the park unit already has led to visible sediment deposits in the park after storms, NPS personnel have been working actively with the county, developers, and other groups to effect better conservation practices upstream. In one case, developers of a subdivision near the park already have improved their erosion control measures after park personnel pressed for such action.

Figure 1. *Upstream urbanization evidently is causing the channel gouging seen here along Poore Creek in Petersburg National Battlefield.*

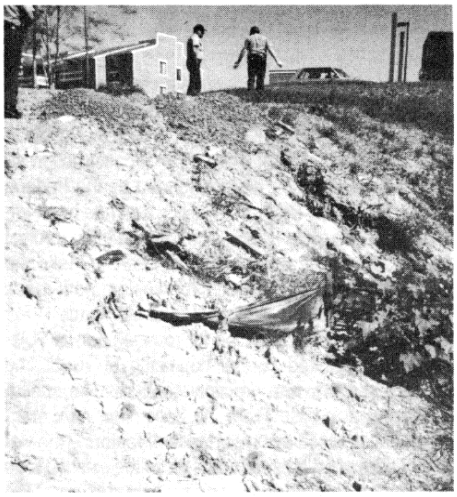

Figure 2. *Housing construction can cause erosion, which flows as sediment downstream during storms. This eroded site is only about 100 meters from the park boundary at Richmond National Battlefield Park.*

Possible Conservation Measures

More effective conservation measures must be implemented by upstream developers in order to protect resources at both Richmond and Petersburg. Developers can take many kinds of conservation actions, such as leaving undeveloped "buffer" strips along streams; using better erosion control and sediment retarding devices; building runoff retention ponds to diminish peak runoff, and incorporating improved development planning. Forcing upstream developers to take conservation actions can be difficult unless a park has some accurate quantitative data to demonstrate beyond a doubt that a problem exists. Therefore, the two parks initiated these studies to evaluate and quantify some of their urbanization-caused impacts.

At Petersburg NB, Dr. James D. Gregory and Research Assistant Charles A. Williams, hydrologists from NCSU, have coordinated the technical work including the data analysis. The park staff responsible for data collection are Rangers Karl (Chuck) Smith and Allan Morris. Sam Kunkle of the NPS Water Resources Division, Fort Collins, Colorado, worked with the park and with John Karish of MARO to develop the original concepts for the project. At Richmond NBP, Chief Ranger Chuck Rafkind has been the primary person involved, with work also carried out by David Shockley, Dan Roddy, and Erv Gasser of the park staff. Gregory and Williams of NCSU also have provided technical advice to Richmond NBP staff on ways to measure sediment deposition.

Questions on techniques being used at these parks can be directed to J.D. Gregory, Department of Forestry, NCSU, Box 8002, Raleigh, NC 27695.

James D. Gregory is Associate Professor, and Charles A. Williams is Research Assistant at the School of Forest Resources, NCSU; Karl Smith is Ranger, Petersburg NB; Chuck Rafkind is Chief Ranger, Richmond NBP; Sam Kunkle is Land Use Hydrologist, Water Resources Division, NPS; John Karish is Regional Scientist, Mid-Atlantic Region.

Soleduck Revegetation Project

By Nancy Dunkle

In early November 1986, construction began on approximately fourteen miles of the Soleduck Road between Highway 101 and the Soleduck Resort in Olympic National Park. Part of the reconstruction effort is a revegetation project, funded by the Federal Lands Highways Program (FLHP), that has been underway since July 1985. The revegetation project began as part of a more general effort to make the new Soleduck Road a model for western park roads designed under the 1984 park road standards.

Planning and preparation for revegetation at Soleduck has required careful balancing of visual and ecological goals with practical concerns like speed, efficiency, and cost. From the beginning, park management stressed the importance of restoring the visual qualities that are characteristic of the existing road (i.e., the variety, diversity, and random pattern of the native forest edge communities). Management also supported "hands on" experimentation aimed at developing efficient and practical methods of using native plants in revegetation. In addition, project planners were committed to approaching these goals in ways that help to protect the genetic diversity and integrity of the Soleduck Valley plant communities.

Although the long-term revegetation objective is reestablishment of native edge communities similar to the ones that occur on existing cuts and fills, this aim cannot be achieved in one or two years. Clearing and grading make environmental conditions on the reconstructed slopes less favorable to forest edge species than to native pioneers or weedy exotics. It is hoped that treating the newly graded slopes to make conditions more favorable for forest species and replanting natives to give them an advantage over weedy exotics will allow forest communities to reestablish quickly.

One method of slope preparation incorporated into the road construction contract specifications was to require the removal and stockpiling of 4,000 cubic yards of duff, litter, and woody debris from old growth forest stands within the project clearing limits. This material will be spread to a depth of six inches on selected reconstructed slopes adjacent to old growth forest stands. A planting medium of native duff, litter, and course woody debris not only alters environmental conditions to favor forest edge species, it also is a source of seed from local genetic stocks. Another benefit is the mulch effect which protects slopes from erosion. Finally, the texture and appearance of a slope treated with this material are more compatible with the visual characteristics of the adjoining forest than smooth newly graded slopes or hydroseeded grass.

Although replacement of duff and litter is the preferred approach in areas where aspect and narrowness of clearing limits will produce full or part shade, it does not work well in areas that receive full sun or are steeper than 1.5 to 1. Because it is also relatively expensive, duff and litter replacement is being reserved for old growth areas where it can be used to maximum effect.

A variation on hydroseeding (the most inexpensive slope preparation), developed by park botanist Ed Schreiner, is aimed at minimizing its negative effects. He proposed seeding with a mixture of fast-growing, short-lived annuals and cereals to provide initial erosion control. Since unfertilized hydroseeded grass mats are known to begin deteriorating after about two years in the Pacific Northwest environment (Dyrness, 1975), it was hoped that these grasses would not persist at Soleduck. The deteriorating mat would then provide organic matter and seedling establishment sites for natives.

A modification of Schreiner's approach currently being considered involves seeding a sterile wheat hybrid (*Triticum x Agropyron*) in combination with two native grasses. The sterile wheat establishes quickly like its cereal parent but it cannot reseed itself. The two native grasses (*Bromus vulgaris* and *Elymus glaucus*) have been collected from the Soleduck drainage. Negotiations have begun to have these seed stocks increased by growing them in isolation at the SCS Plant Materials Center in Corvallis, Oregon. Neither species is particularly competitive with woody natives.

In addition to site preparation, project plans include replanting over 20 acres of cut and fill slopes. To obtain local genetic stock for this effort, much of the 1986 field season was spent (1) salvaging native plants from areas scheduled to be cleared during construction, (2) collecting native seed, and (3) propagating native plants through hardwood and semi-hardwood cuttings. Because many of the reconstructed road shoulders will be drier and more open than the existing road, emphasis was placed on dry site species and natives with some degree of sun tolerance. Shade-loving dormants like western hemlock (*Tsuga heterophylla*) and shallow-rooted mat-forming herbs like *Oxalis oregana* can also be planted close to the forest edge or on areas where slope orientation and narrow clearing limits will produce adequate shade.

Between June and August 31, 1986, a six-person revegetation crew assisted by nine YCCs removed over 11,000 plants from within the construction clearing limits. Most species were moved as individual transplants, but, in some areas, shallow-rooted mats containing several species could be cut and rolled like sod. All plants were heeled in trenches at 33 nursery areas located from 10 to 50 feet behind the clearing limits. These sites were watered about once a week during July and August. In mid August, when plants began to show signs of transplant shock, salvaging stopped. Mid-September mortality data showed over 95 percent of the transplants were still living.

Reveg crew member *Dick Hadley collecting* Anaphalis.

Thirty species were represented. Sword fern (*Polystichum munitum*), western hemlock (*Tsuga heterophylla*), and pearly everlasting (*Anaphalis margaritaceae*) accounted for over 70 percent of the collection. In selecting species to transplant, the crew tried to salvage in proportion to what would be needed in revegetating and to preserve the diversity of species along the road. They also concentrated on plants that transplanted well, particularly community dominants like sword fern and hemlock. Also emphasized were dry site species such as pearly everlasting, salal (*Gaultheria shallon*), and Douglas fir (*Pseudotsuga menziesii*); mats of shallow-rooted herbs, especially aggressively rhizomatous species,

Close up of *shallow-rooted mats of Oregon oxalis (*Oxalis oregana*) with interspersed foam flower (*Tiarella trifoliata*) in salvage site nursery.*

Soleduck *(continued)*

and slow-growing, usually woody species that cannot easily be propagated by seed. To increase diversity, the crew attempted to transplant any species not previously encountered.

In August, the emphasis began shifting from plant salvage to seed collection. Seed from 24 species was collected and cleaned. Because maximum diversity was desired, an effort was made to collect each species from a variety of locations and habitat types. Early and late ripening fruits of the same species were collected. Seed from tall and short individuals of the same species was sought.

The collected seed will be propagated in a number of ways. A contract is being negotiated to have 8,500 salal plants and seedlings of other species grown from Soleduck Valley seed by a commercial nursery. Three species will be tested and grown for production by a local high school horticulture class. Ten species are being used in field germination test plots on cut slopes on the neighboring forest service road. The project staff will use the remainder for additional germination tests and fall-sowing for production.

Propagation from cuttings has also been attempted. In April 1986, hardwood cuttings were taken from 10 woody species. They were planted and are being cared for under contract by Diversified Industries, a local sheltered workshop. Species that rooted and showed over 50 percent survival include flowering currant (*Ribes spp.*), Snowberry (*Symphoricarpos albus*), and dogwood (*Cornus stolonifera*). Over 20 percent of Thimbleberry (*Rubus parviflorus*) and Salmonberry (*Rubus spectabilis*) cuttings survived. In August, more than 2,100 semi-hardwood cuttings representing six species were collected and are being cared for under mist in polypropylene tents.

As work progressed, records were kept on the time and costs needed to salvage or propagate native genetic stock. In the case of sword fern, an important community dominant, salvage appears to be clearly cost effective. Sword fern purchased for visitor center plantings cost $9 per two gallon container for plants in excellent condition. The cost of salvaging a large sword fern with a good root ball was between $.85 and $.39 a plant. Even if the cost of a container were added, this would still be a considerable saving. As previously noted, transplant survival is at least 95 percent and all plants are from the Soleduck gene pools. Preliminary figures suggest that, for a number of species, salvaging local genetic stock can save money, if a particular species transplants easily. The cost of growing natives from seed is also reasonable. Year-old containerized evergreen seedlings can be grown by contract for around $125 per thousand. Year-old woody shrub seedlings such as salal in 4 to 10 cubic inch containers are estimated to cost about $.62 per plant not including the cost of collecting local seed. Whatever method is selected, the importance of adequate time for planning and preparing a revegetation project is critical. Although some species can be contract grown in a year's time, at least two years lead time is recommended.

During the 1986 field season, work with slope preparation and native plant materials laid the ground work for achieving the project's visual quality goals. The staff found that much of this work could be done in ways that consider the genetic integrity of the ecosystem, but do not generate excessive additional costs. As work proceeds and more results are available, we hope that the standards we test will be useful to future road projects in the National Park system and beyond.

Dunkle is an NPS Environmental Specialist at Olympic N.P.

Using 35mm Color Infrared Slides To Map Vegetation

By Alison Teetor

Vegetation maps are becoming an increasingly important tool in resource management. Development of these maps often involves manual interpretation of aerial imagery in conjunction with ground work to verify the actual forest cover. Using stereoscopic pairs of 9″ x 9″ photographs has been the standard technique, but a new approach, developed by the Virginia Commission of Game and Inland Fisheries (VCGIF) utilizes 35mm color infrared (CIR) slides. Shenandoah National Park (SNP) began mapping its 195,000 acre land area in 1983. Slides were chosen because the overall cost was substantially lower than other available aerial imagery. As of January 1986, two-thirds of the park had been mapped using CIR slides, field checked, and tested for accuracy. This article describes the methods, advantages, and disadvantages of using this technique.

Study Area and Methods

Shenandoah National Park is located in the Blue Ridge Mountains of Virginia. The park contracted with the VCGIF to obtain CIR imagery over a three year period. Approximately 3500 slides were required to provide complete coverage. Slides had the standard 60 percent overlap and 30 percent sidelap, and covered about 430 acres each. As with photographic imagery, reflights are often necessary as complete overlap is difficult to obtain with one flight and gap areas cannot be identified until after the area has been mapped. Total cost of the slides was $8700.00. Table 1 outlines the costs of obtaining CIR slides compared to 9″ x 9″ photos.

The CIR slide method of vegetation mapping involves several steps. The imagery must be obtained, the slides are then interpreted, and draft maps are produced. The maps are verified on the ground by extensive plot sampling, rechecked, and corrected. Finally, the maps are tested for accuracy.

A plane, pilot, photographer, and camera equipment, essential for obtaining aerial imagery, may be available through other federal or state agencies doing aerial photography in the area. Often, however, this service must be contracted to private aviation companies specializing in aerial photography. The plane used must be equipped with a camera port in the bottom of the fuselage, and a special photo platform manufactured to hold the camera. For large land areas, the camera system must be capable of taking 250 pictures/roll of film with an electric timer calibrated to the speed of the aircraft to obtain the desired exposure sequence, (usually, 8-10 frames/minute) depending on airplane speed, altitude, camera equipment, and desired overlap (Martin, 1982).

The basic equipment needed to interpret slides is a slide projector and viewing stand (Fig. 1). The slides are projected to the ground glass screen. A mylar film with the topographic features covers the screen, and the slide is aligned to the topography. Forest stand boundaries are delineated directly onto an additional mylar sheet positioned over the topographic sheet. The viewing stand was adapted by the VCGIF from a projection system developed at the University of Minnesota (Meyer, 1978). With the specialized glass plate, its cost is approximately $150.00. Information regarding the construction of a viewing stand may be had by writing the author.

Identifying Forest Cover Types

The slides were taken at an average altitude of one mile above ground level. This provided imagery that could be interpreted at a 1:12,000 scale. A minimum stand size of 3-5 acres was established since this was the smallest area that could be accurately identified. It was also determined that only the central portion (65%) of the slide could be evaluated to avoid extensive scale distortion caused by changes in ground elevation.

The range of scale for 35mm slides runs from 1:600 to 1:20,000. The larger scale enhances detail while the smaller scale provides complete coverage with fewer numbers of slides.

Results

The forest cover of SNP is representative of the eastern deciduous forest community. This forest type is one of the most diverse in the United States. To

Table 1. Cost comparison for obtaining 35mm CIR slides versus 9″ x 9″ photos, for the 195,000 acres of Shenandoah National Park, VA. 1986.

ITEM	35mm SLIDES	PHOTOGRAPHS
Film Processing & Handling	CIR Film – Special Factory Order Eastman Kodak Co., Rochester, N.Y. Catalog no. 152-5203 Aerochrome Infrared Film 2243 Estar Base – 135mm 150 foot rolls – $72.48/roll 45 rolls **TOTAL $3300.00**	False Color Infrared Title negatives **TOTAL $1404.00**
Airplane & Pilot Rental	Based on an average Park dimension of 105 x 10 miles Approximately 10 flight lines 18 hours at $55.00/hour **TOTAL $3950.00**	Same average dimension and flight lines **TOTAL $13,660.00**
Film Processing & Handling	Lightwork Lab 509 NW 10th Avenue Gainesville, Florida 32601 $30.00/roll mounting and handling not included, 3500 slides **TOTAL 45 ROLLS $1450.00**	One set 9″ x 9″ transparencies 1404 exposures **TOTAL $8424.00**
	TOTAL $8700.00	**TOTAL $23,488.00**

Infrared Slides *(continued)*

date, two-thirds of the park has been mapped using CIR slides, and seven dominant cover types were accurately identified an average of 70 percent of the time (Garner and Vaughan, 1985, Teetor, 1985). Delineation of forest cover types is based on slide color, texture, and knowledge of where individual cover types are likely to occur relative to site conditions (Garner, et. al., 1983). Extensive field verification is a necessary component of this method and about half of the stands outlined were visited on the ground. The remaining 65,000 acres was mapped during the summer of 1986. The project completion date is May, 1987.

Advantages

The most obvious advantage of using slides is cost efficiency. Not only is the cost of acquiring the slides much lower than for the 9″ x 9″ photos, equipment used to interpret the slides is less expensive. This relatively low cost allows imagery to be taken more frequently to provide a better record of forest cover defoliation, recreational development, and land management practices over time. In SNP, slides were taken in the summer to evaluate the dominant canopy coverage and during the winter to evaluate evergreen understory distribution. In addition, small land areas (‹100 acres in size), such as unique natural features can be mapped using CIR slides, in these instances the imagery is easily acquired and interpreted by land managers.

Disadvantages

The use of slides involves some reduction in detail, since the projected slide has a surface area of about 4″ x 6″ compared to the 9″ x 9″photo. Although 35mm cameras are capable of producing photography, there is a sacrifice in definition that goes with using smaller camera equipment and large areas would be difficult. Detail is reduced in the slide methodology, which is incapable of 3-D interpretation, compared to the stereoscope capability which also can magnify the 9″ x 9″ photographs to 2 to 6 times their original size. Distortion is a potential problem, but this is also a problem with photos. The set up used to interpret the slides requires that the projector be manually manipulated to correct the scale . . . a somewhat tedious procedure but one that does effectively eliminate scale distortion. Another problem in using CIR slides is finding a place to have them processed (Martin, pers. comm.). Most film processing companies are not set up to handle the long roll length. SNP used a specialty lab in Florida. However, short rolls of 36 exposures may be developed in many locations. Costs for development are dependent on how the slides are mounted and handling fees.

Conclusion

CIR 35mm slides can provide an economical alternative to using stereoscopic 9″ x 9″ photos. Good quality slides provide an easy, efficient way to map large or small land areas without the costs of expensive equipment. Land managers will find this technique useful for interpreting vegetative cover, the effects of land management such as prescribed burns and land development, and the changes occurring as a result of insect defoliation.

Teeter is a Forestry Technician at Shenandoah NP.

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letters to the editor

To the Editor:

The National Park System Advisory Board's September 1986 "Report on 'Overcrowding' in the National Parks" does not pretend to be a scientific document, but its treatment of science is most unsettling. The report correctly points out that many problems can be mitigated by redesign and/or alteration of visitation patterns and that raw numbers of visitors do not necessarily constitute overcrowding from a sociological or ecological perspective. Furthermore, the report notes that increased staff and knowledge can be utilized to reduce visitor impacts.

However, the report is seriously flawed. It is instilled with logical defects and substantive omissions that cast doubt upon its objectivity. It states that overcrowding is imprecisely definable and is "based on individual perspective and varies with location." It goes further to state that "little if any data exist to indicate the effects of public use on natural and other resources." How is it that the Board can act (or base conclusions) upon assessments of an assertedly undefinable concept; one that in its own judgment, has been only superficially studied? The Board does so by reducing the park environment to the physical tourist facilities provided to accommodate visitors; and by claiming ignorance of the body of literature that relates human influence to park ecosystems.

This is totally unacceptable and is a direct affront upon the principal mission of the National Park Service. The statement that "except in extreme, dramatic cases, the use of 'carrying capacity' as a scientific justification for imposing restrictions on visitor use will probably not be widely accepted by park users in the near future" is blasphemous (neither is it likely that the Bill of Rights could pass a plebiscite). The National Park Service has a clear mandate "to conserve the scenery and objects" it stewards. Use must be congruent with that objective. We cannot ignore demonstrated use/impact relationships, nor where suspected, fail to conduct inquiries to determine their extent.

It is more accurate to state that park managers, when confronted with scientific data on the relationship between visitor use and impact are hesitant, unwilling or unable to make the hard decisions necessary to protect park resources because of external political considerations than to say that the data upon which to base such decisions do not exist.

Science can only rarely tell a manager how much is too much. However it can often paint a good picture of the influences of his actions (or inactions) on the resource.

The Advisory Board must broaden its perspective for its findings to become valuable contributions to the many questions at hand.

Steven H. DeBenedetti
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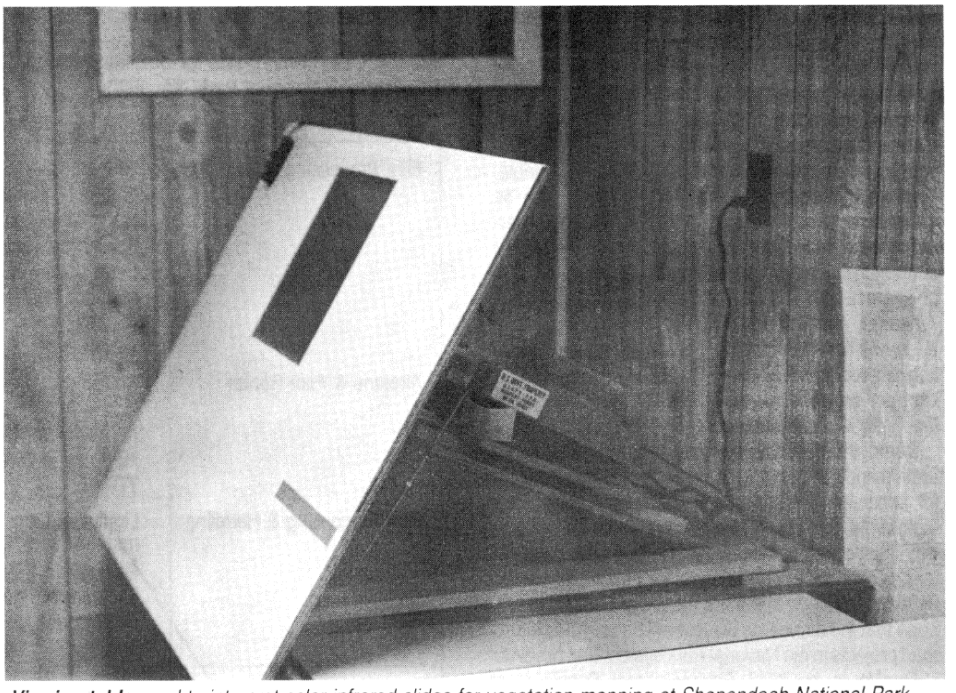
Editor's Note: The NPS Advisory Board Report referred to here appears in its entirety in the current issue of the George Wright Society FORUM (Vol. V No. 2).



Viewing table *used to interpret color infrared slides for vegetation mapping at Shenandoah National Park.*

mab notes

At the Dec. 18-19, 1986 meeting of the U.S. MAB-8 Directorate on Biosphere Reserves, members rated proposed projects for 1987. Among those receiving the highest ratings, and thus top contenders for 1987 funding through the U.S. MAB Secretariat, were the following:

Development of a model biosphere reserve. The program needs an exemplary biosphere reserve that fully carries out the intended functions and objectives as described in UNESCO's 1984 Action Plan for Biosphere Reserves. The Southern Appalachian Biosphere Reserve Cluster (see below), which includes Great Smoky Mountains NP, was recommended as the pilot project site because of its history of MAB activities, the research potential of institutions forming or expected to join this biosphere reserve cluster, and the existing institutional framework for regional and international cooperation. This project was proposed in a 1986 paper by Tommy Gilbert, former NPS MAB Coordinator and now an environmental consultant in Gatlinburg, Tenn.

Revision of U.S. biosphere reserve selection guidelines. Such a revision is needed to consolidate separate guidelines for selection and management of inland and coastal areas and to reflect recent U.S. experience and guidance of the Action Plan for Biosphere Reserves and recommendations of the Scientific Advisory Panel on Biosphere Reserves.

New biosphere reserve nominations. The Directorate approved the report of a Canadian-U.S. MAB panel for the Lake Forest Biogeographical Province, which encompasses the mixed hardwood forests along both sides of the international boundary from Minnesota to the Maritime Provinces. The report identifies seven biosphere reserves, each consisting of a cluster of nearby or contiguous sites, as suitable for nomination. If administrators endorse the panel's recommendations, Voyageurs NP would be included within a multi-site biosphere reserve also including the Boundary Waters Canoe Area Wilderness (Forest Service), Quetico Provincial Park in Ontario, and Isle Royale NP, an existing biosphere reserve. The Directorate recommended that administrators be requested to identify preliminary ways in which they plan to implement biosphere reserve concepts, and that MAB offer to assist in identifying opportunities through workshops, public meetings, or other means.

The Directorate also endorsed the recommendation of a recent MAB panel that the biosphere reserve now consisting of Great Smoky Mountains NP and Coweeta Hydrological Laboratory be expanded to include the Oak Ridge National Environmental Research Park, several North Carolina state parks, Roan Mountain, the Grandfather Mountain area, and parts of the Cherokee, Pisgah, and Nantahala National Forests. This would be called the Southern Appalachian Biosphere Reserve. Administrators of all these sites except Roan Mountain and the National Forest areas have endorsed the incorporation. As of December 1986, biosphere reserves have been designated in 19 of the 25 biogeographical provinces, and 9 of the 13 coastal regions wholly or partially included within the U.S. and its territories.

Biogeographical classification of coastal/marine areas. The Directorate endorsed a proposal to develop a pilot, ecologically-based classification of the Caribbean as a model for similar projects elsewhere. Such a classification is needed for selection of coastal/marine biosphere reserves.

Biosphere reserve brochures. An international BR brochure, funded by UNESCO and U.S. MAB and written largely for public and private agency officials, is nearing completion. New funding is needed for a proposed brochure on U.S. biosphere reserves that would be directed mainly at reserve visitors and BR staff.

Smithsonian/MAB Biological Diversity Program. A standard protocol for conducting biological inventories is being developed and pre-tested in Peru. Initial field training workshops to test all aspects of the system will begin in biosphere reserves and other species-rich areas in mid-1987.

U.S. inventory of macroreserves. The statewide Florida pilot project is scheduled for completion in mid-1987. The MAB-8 Directorate suggested that the Southern Appalachian region be surveyed next.

Sonoran Desert BR program. Efforts are underway to link Organ Pipe Cactus NM, an existing biosphere reserve, with the adjacent Cabeza Prieta Game Range, administered by the U.S. Fish and Wildlife Service, to form a Southern Arizona Biosphere Reserve. Pinacate Natural Park, a contiguous area in Mexico, is a potential future addition. U.S. and Mexican specialists are writing a reference text on the ecological and cultural importance of the area. This is intended to be a catalyst for eventual creation of a transborder Sonoran Desert Biosphere Reserve.

Napier Shelton
NPS Washington Office

book review

Up on the River: An Upper Mississippi Chronicle by John Madson. 1985. Nick Lyons Books, New York. 276 pp. (ISBN 0-8052-3966-9).

John Madson's *Up on the River: An Upper Mississippi Chronicle* is a folksy, highly readable and exceptionally accurate guide to the Upper Mississippi River (from St. Louis to Saint Anthony Falls). In it, Madson dramatically summarizes the geological, biological and human history of America's most famous river, one so famous it is simply called "The River". This carefully crafted and authoritative work brings us up to date from where Mark Twain left us off a century ago.

The Upper Mississippi is an incredibly exquisite natural resource, and along its banks there has evolved a unique and timeless culture. *Up on the River* is an accurate portrait that captures the essence of both the natural and cultural worlds, demonstrating how each has influenced and shaped the other.

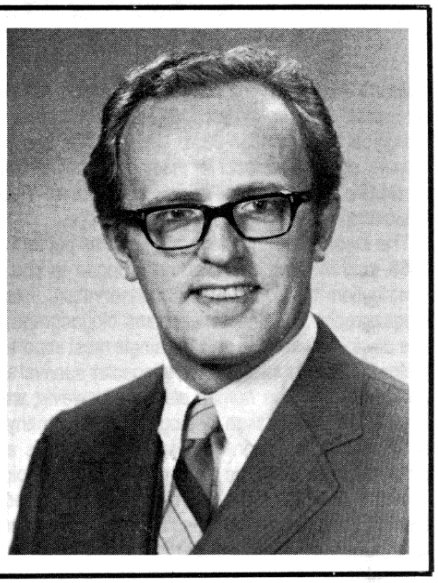
Madson takes us from the "Old River" with its clear waters, beds of Higgin's eye pearly mussels and 150 pound sturgeons to the "Modern River" with its dams, carp and recreational boating. He dramatically summarizes the River's long use and abuse by lumberjacks, shell gatherers (who used the shells to make mother-of-pearl buttons), barge men, fishermen, and the Army Corps of Engineers.

Up on the River is sometimes hilarious, it is masterfully written, and it is always accurate. Anyone who cares about the natural world of the Upper Mississippi and the independent people who inhabit its banks would do well to read Madson's account; those who don't care yet surely will after a very pleasant evening or two with what has to be one of John Madson's finest works.

Note: John Madson is a well known writer in the field of ecology and the outdoors. His articles appear regularly in such publications as *National Geographic* and *Audubon*. Previous books by Madson include *Out Home, Stories from Under the Sky* and *Where the Sky Began*.

Thomas W. Lucke, *recently of Fort Collins, Colorado, formerly of Bellevue, Iowa, an Upper Mississippi River town.*

Tom Lucke, 1940-1987



Thomas W. Lucke, Chief, Water Resources Division for the National Park Service and member of the *Park Science* editorial board, died suddenly on February 25, 1987. He was 46. A 20-year veteran of the National Park Service, Tom's previous assignments included Mesa Verde National Park, CO (Interpretation), the Western Regional Office, San Francisco, CA (Land Acquisition), Buffalo National River, Harrison, AR (Legal Assistant), Fort Larned National Historical Site, KS (Supervisory Park Ranger), Denver Service Center, CO (Cultural Resources Management Specialist), and the Southwest Regional Office, Santa Fe, NM (Chief, Division of Environmental Coordination). Prior to his coming to the National Park Service, Tom served two years as a Peace Corps volunteer in Nepal.

A native of Bellevue, Iowa, Tom received his B.A. in classics and history (1963) from Loras College, Dubuque, Iowa; a M.A. in history (1965) from the University of Colorado; and a J.D. (1971) from the College of Law, University of Iowa. He was a life member of both the Association of National Park Rangers and the NPS Employee and Alumni Association. He was recently appointed Trust Fund Officer for the Employee & Alumni Association. His energetic dedication to excellence will be sorely missed in the myriad NPS areas where he operated. A book review by Tom appears on this page.

Tom is survived by his wife, Liz, and three children, Anne, David and Robert, of Ft. Collins, CO; his parents Esther and Robert Lucke, his brother and sister-in-law, Bob and Judy Lucke, all of Bellevue, Iowa; a brother Will Lucke and sister Ann Benson, both of Denver, CO. The family requests that in lieu of flowers, donations be made to the Employee's and Alumni Association Education Trust Fund, P.O. Box 1490, Falls Church, VA 22041.

The Boundary Approach To The Analysis Of Conservation of Nature Reserves

By Christine M. Schonewald-Cox and Jonathan W. Bayless

Editor's Note: *The full articles from which this was excerpted has been accepted for publication by* Biological Conservation *38(4), pp. 305-322, and Salwasser, et al.: A protocol for institutional coordination in wildlife conservation. In ed. M.E. Soule,* Viable Populations, *Cambridge Press, Cambridge.*

The theory of island biogeography was put forth in 1963, and in the 1980s we finally began to see its contribution to research and conservation. Island biogeography is a fine concept and biogeography a fine discipline – lacking only the single most important factor that stands in opposition to species survival and park protection: the *human element.* However, were it not for initiatives taken by biogeographers, many of us interested in design and protection of parks and other reserves would be looking for a starting point.

In the National Park Service, we have correctly identified people and their effects as the primary threat to endangered species in particular and to parks in general. The disciplines of ecology and biogeography take into consideration only non-human animal species in the contributing theories to conservation biology. Both disciplines are essential, representing underlying systems in the same way that physics and chemistry underlie biology. But decidedly the most important variable to park preservation is the human response to the laws protecting park resources including the uses of lands external to parks. These resources comprise the most powerful inducements to ecological change. So, even ecology and biogeography are not sufficient in the planning or analysis of protection.

With this in mind, we have developed a "model" and an approach to the design and conservation of nature reserves. The approach is a geographic one that brings together the multi-disciplinary aspects of conservation, including humans, their effects, influences, and attitudes besides the traditional biological sciences. This approach recognizes physical qualities of the environment, the biological role of enforcement and resources management in park protection, and focuses on **the administrative boundary** as one of two major thresholds across which numerous constructive and destructive processes occur.

The administrative boundary is like a filter. It separates two types of human social activity. While on the outside, people may farm, build cities, hunt and gather, they may not do so on the inside. The rules that govern human behavior on the inside, once people cross the administrative boundary of the park, constitute the filter. If the rules are enforced, the filter is effective; thus, enforcement "activates" the filter. The filter controls only humans and/or human behavior. Neither animals nor plants, wind nor water can read or heed the exit and entrance signs.

While enforcement activates the filter, resource management responds to the effects of human behavior that move through the filter. When people release exotic species into the park, management responds by attempting to remove the species. When people break through the filter and are found poaching in the park, enforcement attempts to remove and punish the people. What occurs at the administrative boundaries of a national park is a series of opposing forces interacting across the administrative filter. The net sum of these interactions is the effectiveness of park protection for each protected species, item, incident, and/or location. (Fig. 1)

What park relevant changes are induced by the filter processes?

The first change is the development of a "generated ecological edge," the result of activation of the administrative boundary filter. This edge is the second threshold and acts as the "ecological" filter affecting directly species movements and survival. It is different from the so-called 'natural ecological edge," but is often mistakened for it. The development of a generated edge may stimulate the development of additional "secondary" changes we associate with natural edges. The two may overlap each other. The generated edge responds primarily to human effects. The generated edge is of varying thickness and the area between the two sides of the generated edge is subject to segmentation along the perimeter of the park administrative boundary; it constitutes a new and different context for approaching preservation.

The development of segmentation of the edge and boundary, results from variability in land use and biotic communities developing in response to the ownership and use patterns of the land surrounding the park, and from enforcement, zoning and management within the park. All of these factors together give the boundary a *segmented* quality, with each boundary segment a separate habitat, requiring more or less management and more or less protection. Some segments can be identified as "leaks", where erosion of inner resources is taking place. Other segments can be shown to be very steep in contrast from inside to outside and therefore are tantamount to unsupported dams--ready to collapse. The generated edge holds similar properties with regard to segmentation.

The third change that develops is establishment of a gradient across the edge segment – a gradient of increasing density to decreasing density, or vice versa, for a particular species or distribution. The nature of this gradient indicates the potential risk of invasion or loss. For example, where a very high concentration of a species (such as an exotic) exists outside and no concentration exists inside the park, the potential for an invasion exchange is very high. If the gradient exists over a large (shallow) distance (from outside to inside), the exchange is likely to be slow and potentially easier to control. If, however, it takes place over a small distance, it is likely to be comparatively rapid. Persistence of the exotic also has an effect (augmenting the potential for exchange). This suggests that national parks should try to maximize the distance across such gradients where the gradients are steep. The creation of buffer zones is especially important in these situations. And, these should be adapted, as feasible, to segment characteristics.

In cases where little or no gradient exists, there is either no protection (effectively speaking) or little or no need for a buffer or for management and enforcement at the site (for the moment!); namely, the inside and outside habitats are in the same condition relative to internal protection. Unfortunately, the characteristics of gradients are subject to constant change and need to be monitored.

Boundary Processes

Our conception of our protective function is that it is both active and passive. Protection affects internal and external processes that contribute toward or undermine protection of the park. Below are some ways in which changes in the park condition take place.

1. Organisms dependent upon the park's protection may move freely across the boundary but return in smaller numbers than when they exited (less protection outside) (e.g., prairie dogs, alligators, grizzly bears);

2. Organisms in the park may not move freely across the boundary, or may be lost completely when crossing the boundary to the exterior and are, consequently, isolated (e.g., bison, swamp orchid, redwood);

3. Organisms undesired by the park may move freely across the boundary and reduce populations of other species that are dependent upon protection for

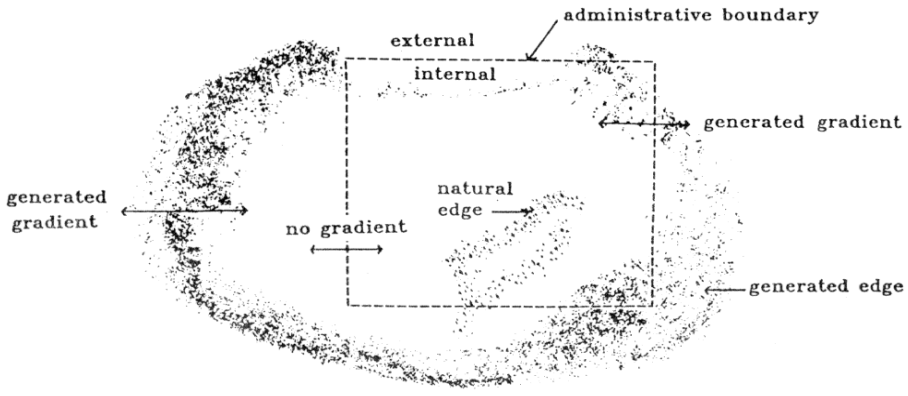


Figure 1. This hypothetical reserve illustrates the variable location of generated and natural ecological edges with respect to the administrative boundary. The generated edge develops in response to enforcement of regulations associated with the administrative boundary. Generated gradients are mapped perpendicularly to the length-axis of generated edges. Where there is no generated edge there is no generated gradient (from Schonewald-Cox et al, *Biol. Cons.* 38:305, 1986).

The Boundary Approach

Continued from page 8

survival (e.g., kudzu, honeysuckle, starlings);

4. Humans may move across the boundary and defy regulations to remove desired organisms that depend upon protection for survival (e.g., cactus, parrots, tree snails);

5. Humans may intentionally or accidentally import organisms that may cause internal losses (e.g., gypsy moth, japanese beetles, feral cats, brook trout);

6. Humanly generated pollutants may enter, move over, seep, or flow into the protected system and change microclimates, flora and faunal distributions, or the food and water supplies, reducing survival of organisms dependent upon protection for survival (e.g. trail erosion, acid rain, off road vehicles, cave lichens and mosses brought in by human hair and skin flakes);

7. People may independently buy land or engage in activities outside of the park that are intended to expand the park's protection and increase its effectiveness (such as has been encouraged by Nature Conservancy or Sierra Club);

While a few species may be isolated, the ecosystem within a park is never cut off completely from its surroundings. So, total genetic isolation of most park species is not likely to occur. On the other hand, humans and their effects are quite capable of intruding into every known isolated area on the face of the earth. The extent of isolation of the park community can be described by patterns of species distributions and movements in relation to the park, as seen in vegetation mapping and monitoring.

As mentioned earlier, rate and ease of movement of organisms across the administrative boundary filter is influenced by the generated edge. In addition, the number of individuals moving across the administrative boundary is affected by classic measures such as group size, average distance maintained between individuals, manner of obtaining resources, susceptibility to competition and predation, species mobility, amount of directional movement, population density gradient, the nature of any coinciding natural edges with the generated edge, suitability of habitat within the generated edge, and human influences that encourage or discourage movement.

For example, organisms that form associations or clones will tend to move into habitats that are not saturated. The movement may be reversible, but movement overall will tend to favor one direction in the short term. Directional movement can also be manifested for species that are dissipated when they leave the park under conditions such that none return. If recruitment does not compensate for this directional movement our of the park, then the species is extinction prone.

Several reports in the last five years suggest tremendous pressure from external impacts. Those that traverse park boundaries and come into the park accelerate losses not only across the boundary (by movement) but also within the park by reducing recruitment and survival. It should not be overlooked that tourism in the National Parks constitutes a multiple use industry that can severely impact park resources from within, bringing the generated edge into the center of the park and threatening to make protection ineffective.

Shape and Size of the Protected Habitat.

We recently measured roughly the area-to-perimeter ratios (A-P) for 106 of the most sizable parks in the National Park System. An A-P ratio of 5 describes a park that is almost linear, essentially; there were 10 of these.

In the A-P = 15 ratio, were 22 parks. Only 11 parks showed an A-P ratio of 25 or higher, constituting essentially round or square parks. Between the A-P = 15 and the A-P = 25, fell 54 of the parks.

What this means is that in terms of the boundary effect, most of the parks in the National Park System are highly exposed; i.e., there exists only a short distance from any interior point to an administrative edge. These parks will need strong cooperation among all elements of the full park staff and between them and surrounding land owners and managers.

The most positive avenue for dealing with exposure seems to be cooperation with adjacent land agencies to create buffers surrounding the most vulnerable segments of the administrative boundary and a resource management effort to push the generated edge outward, so that the gradient becomes so shallow as to be almost undectable.

If two areas adjacent to each other cooperate in protection (even if the work is done in slightly different ways) the generated edge then may coincide with the outer boundaries of their combined units.

If adjacent areas are not available, it's important that parks begin to look into techniques of gene flow used by the leading zoological parks and botanical gardents for species at risk. While such manipulation of populations is not preferred, sometimes there is no alternative if a species evolution is to continue. Or, we may decide to favor process at the expense of species not deemed important or that we believe are undergoing a natural extinction.

Three important functions associated with parks are enforcement and resource management. Each has a discernible role in determining where and to what extent the generated edge will develop. Enforcement activates the boundary filter and keeps out humans engaged in deleterious activities. Resource management treats the effects of human activities across the filter. Researchers can decipher the impact that the boundary has on the very crucial generated edge. Until now, there has been little recognition of the enforcement, resource management and research roles as part of the biological functioning of the park. The boundary approach to management clearly suggests at least these ecological roles for each of these functions.

CONCLUSIONS

It is likely that the current rate of extinctions cannot by mitigated by merely reducing the impact of area effects resulting from habitat fragmentation. The extinction rate is also influenced by human behavior. How this behavior translates into ecological processes across park boundaries, we believe, will strongly influence the effectiveness of protection.

The boundary model suggests that knowledge of changes in local human activities, traditions and attitudes relating to protection and location of natural and generated edges is critical. Populations in protected habitats may decline dramatically, but extinction is not the inevitable consequence, nor is available habitat size necessarily the limiting factor. The boundary model suggests that the results of studies examining the area effects may inadvertently be confounded by several physical and biological factors and it also reassures us of the proneness of some species to extinction in parks of high exposure and small size – due to stress caused by human generated impacts.

We believe that generated gradients and other components of the boundary model and approach to analysis of protection will alter our views on the probability of extinction in protected habitats. It will make us more aware of the fragility of even the largest protected sites. Incorporation of human societies, behavior, and welfare into the planning and design process in land-based conservation efforts is sorely lacking at present.

We believe that "Boundary" represents an advance derived from synthesis built on the best information present theories have to offer. It has the flexibility to incorporate specific mandates and localities for dealing with real-world conservation issues, and it can incorporate the models and metaphors of numerous contributing disciplines.

Schonewald-Cox is a Research Scientist and Bayless is a Resource Management Specialist at the U/Cal/Davis NPS/CPSU.

computer corner

A software package called "WATER Q" is now available to parks with needs for database management in water quality monitoring. Utilizing the dBASE III database management system, the program is user-friendly and menu driven. WATER Q was written for Mount Rainier National Park by Dr. Richard Frenzel of the Cooperative Park Studies Unit, Oregon State University. Although structured for data collected at Mount Rainer, the program may be used to manage water quality data collected in other areas. Additionally, the Statistics, Data Listing, and Non-system File Creation modules are useful for manipulating data sets other than water quality information.

Main options of the program are data entry, editing data, running statistics and/or listing data, log transformations of data, and creation of non-system ascii output files (for use with other software such as Lotus 1,2,3, graphics packages, etc.). Requirements of the program include:

a) hardware requirements
   IBM or IBM Compatible Personal Computer
   256K bytes of memory
   two 360K floppy disk drives, or
   one 360K floppy disk drive and a Hard Disk
b) software requirements
   MS-DOS or PC-DOS version 2.0 or greater
   dBASE III or dBASE III +

Data fields used are site code, date, sample time, air temperature, water temperature, salinity, conductivity, dissolved oxygen, pH, turbidity, total coliforms, fecal coliforms, fecal streptococcus, alkalinity, suspended sediments, dissolved solids, total N, NH_3, NO_3, + NO_2, total P, PO_4, Si, Na, K, Ca, and Mg. Individuals familiar with dBASE III programming might add additional parameters (program documentation is included in the manual accompanying the software).

Because "WATER Q" was written for and is the property of NPS, it can be furnished at no cost to parks that want it. Send a blank diskette to: Cat Hawkins, Natural Resource Specialist, Olympic NP, FTS 396-4501, COMM (206) 452-4501, or Peter Thompson, Backcountry Specialist, Mount Rainier NP, FTS 390-6393, COMM (206) 569-2211.

Conservation Biology Group Exhibits 'Elastic' Response

A loosely knit, "amoebic" body of research personnel is functioning out of the NPS Cooperative Park Studies Unit at U/Cal/Davis under the designation of "the conservation biology group." Led by Christine Schonewald-Cox, CPSU research scientist, and Jonathan Bayless, NPS resource management specialist, the group draws its members from various agencies and universities according to the job at hand.

"The subject matter is strongly multidisciplinary," Schonewald-Cox explains, "and requires diverse technological talents ranging from remote sensing capabilities to statistical modeling to programming and biological information synthesis."

For boundary work, the team consists mostly of U/Cal/Davis, U/Cal/Berkeley, and U/Ariz (including the NPS/CPSU there) individuals. For small population work, the team draws mainly on its connections to U/Cal/Davis, Stanford, U/Mont, the NPS Denver Service Center and the U.S. Forest Service, with occasional linkages to similar teams at U/Cal/San Diego, U/Mich, and U/Fla at Gainesville.

The group is presently applying for funds from the U.S. Environmental Protection Agency to enhance its ability to measure the effects of park boundary interactions. The money would be used to maximize interagency cooperation in the areas surrounding the subject park and among the vastly different sciences and technologies involved. "We would also seek," Schonewald-Cox said, "to resolve the differences in approaching environments and habitats – subjective differences that stem from sources such as different agency missions and different discipline orientations."

The small population project has received funding support from two NPS Regions – Pacific Northwest and Western – so far in 1987, Schonewald-Cox said. The money is underwriting completion of a carnivore density analysis. "In this project," she said, "we have developed means of predicting or assessing numbers for a given species in relationship to park size. The results have been extremely positive so far, and group members are in the process of writing their scientific papers and management guidelines. The ungulate analysis will take place this summer.

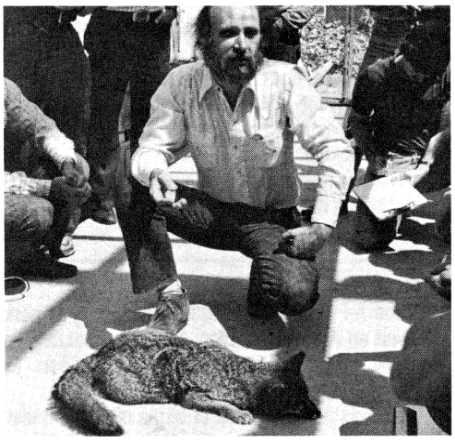
"The technique is to be used in much the same way a pediatrician maps and assesses infant growth – as an indicator of general health, and (in the park's case) of potential carrying capacity. It should lead to more precise definitions of research needs and thus to more efficient use of research," Schonewald-Cox said, "but it will not be used as a substitute for detailed analysis.

At Organ Pipe Cactus National Monument, the group has been digitizing maps showing vegetation, land ownership, zoning, animal species distribution, geology, etc. in and around the parks, including significant adjacent areas. This effort amounts to the first mapping of "the edge" that is generated as a result of park protection and other interacting factors described in the "boundary" paper by Schonewald-Cox and Bayless, (see p. 8).

"Our objective at Organ Pipe Cactus," she said "is first to develop the technique, and then to look for boundary habitat vulnerabilities. We've been slowed by the difficulty of obtaining some of the maps we need, but we expect to have them and to complete the digitizing so that analysis can be launched this year."

Is Our Face Red!

CORRECTION! *If you think you've seen this picture before, it's because you probably have. The editor received the following memorandum from Terry Hofstra, Redwood NP fish and wildlife ecologist: "As we discussed on the phone, there were a couple of errors associated with the photo published on page 9 of the last issue of* Park Science. *First, the individual in the photo was Dr. Richard Golightly of Humboldt State University and not John Sacklin as indicated. (John took the photo). Secondly, the animal in the photo, a grey fox, was incorrectly identified as a kit fox. I understand the text submitted with the photo was misplaced and you attempted to get the correct details by calling our office. We have located and severely thrashed the individual who gave you the incorrect information over the phone.*



In addition to the erroneous caption on the wildlife immobilization training course, the Winter edition of *Park Science* sported at least one more outright goof, plus a questionable call.

First, the goof. In the Pacific Northwest Regional Highlights, the PNR Regional Chief Scientist is referred to as Gary Larson, when as the editor well knows, the gentleman's correct name is Jim Larson.

The call that has been questioned by several *Park Science* readers (and by at least one of the editorial board) was the story on Climbing Safety at North Cascades. There was little or no "science" involved in the article. The emphasis in the winter issue was on visitors and the slip from interpretation to safety was subtle enough to catch the editor nodding. A second look at the whole thing, after being brought to task by several readers and after consultation with the editorial board, has convinced the editor that *Park Science* should confine itself mainly to resource management matters that stem from or depend upon some aspect of scientific activity.

To restate our *Park Science* mission once more, here is the formal Statement of Purpose:

1. To report in lay language and readable format on:
   (a) scientific research within the National Park System
   (b) resources management and planning applications of scientific knowledge;
2. To serve as a source of material for interpretation of park sites;
3. To help scientists, planners, managers, and interpreters keep abreast of the research activities, information, and applications that are occurring throughout the System, and
4. To afford a soundingboard for ideas related to scientific research and resources planning and management.

Five-Year Plan For Biodiversity Action on Track

The "five year action plan" proposal presented to NPS Director William Penn Mott, Jr., by the Director's Task Force on Conserving Gene Pools, (*Park Science,* Winter 1987, p. 9) is moving forward, according to the Task Force leader, Christine Schonewald-Cox. She described one objective as "developing state-of-the-art standards for inventorying and monitoring that would integrate classic I&M techniques with (1) assessment of health and 'viability' for populations (of crucial species) and communities, (2) geographic information systems (GIS), and (3) remote sensing. The methodology for assembling a GIS will undergo some revisions, Schonewald-Cox indicated, to incorporate the dynamic changes that occur across park boundaries influenced by surrounding habitat, a subject of ongoing research at U/Cal Davis and U/Cal Berkeley.

Other objectives of the 5-year action plan include training, translation, and interpretation functions that will be handled by means of workshops, training courses, and video techniques, she said.

In addition, a Director's Steering Committee on Biological Diversity is being established and will meet regularly to offer guidance to the NPS Director on national and international biological diversity issues (including genetic diversity) that involve the National Park System.

According to Schonewald-Cox, the plan is to test the I&M standards and guidelines (above) at a particular park site and adjust them so that they can be applied to other parks. They must be responsive to different budget commitments, park sizes, and mission orientations – "thereby maintaining flexibility for a decentralized System."

The 5-year action plan will proceed, she said, with continuous interchange between its working group and the current NPS I&M projects.

* * *

A relationship between the NPS Denver Service Center's construction branch and the conservation biology group at the NPS Cooperative Park Studies Unit at U/Cal/Davis (see this page), has been proposed to develop alternative recommendations for restoration (primarily of plants) at planned construction sites in National Parks.

Christine Schonewald-Cox, research scientist with the CPSU and spokesperson for the group, described the project as an attempt to develop a set of probable consequences involved in each alternative. The plan will be tested first at Sequoia and Kings Canyon NPs (SEKI), where the DSC construction branch is planning two projects – one at the park's edge, the other within the park.

The roots of this project lie in a SEKI program initiated several years ago, whereby only park-specific genetic materials are used in vegetation restoration work. Being the "right species" but coming from outside the park was not considered sufficient. Seeds are collected from park plants, the Department of Agriculture nurses them to a stage at which they can be transferred to the SEKI nursery and brought along to the point where they can be used in restoring disturbed sites.

Tom Warner, SEKI forester, has agreed to do a *Park Science* article for the Summer issue describing the Western Region's revegetation programs in general and the SEKI nursery operation in particular.

information crossfile

A group of eight NPS professionals met in December 1986 in Washington, D.C. to prepare a task directive for the NPS Director's Blue Ribbon Panel on the 1963 Leopold Report. Two papers, among the products that emerged, appear in the current issue of the **George Wright FORUM** (Vol. V No. 2). One is by Dave Graber, Research Scientist at Sequoia-Kings Canyon NPs, whose assignment was to synthesize the views expressed and come up with a "sense of the meeting." The other is a think piece by Bill Brown, NPS Historian in the Anchorage office of the NPS Alaska Region. The papers were submitted to NPS Deputy Director Denis Galvin, who agreed with the **FORUM** editors that both papers deserved to be published as they were submitted.

⁂

A paper by Vernon C. (Tommy) Gilbert, "Development of a Cooperative Resource Management Project in the Southern Appalachians," appears in the current **FORUM** (George Wright Society publication). It describes the concept of "bioregional" management, the history of its development, and several promising avenues opening into the future. On March 16, 1986, Gilbert discussed the concept with NPS Director Mott, who agreed that models must be developed for NPS cooperation with others in managing natural resources – particularly for biological diversity. Southeast Regional Director Robert Baker has indicated interest in a Southern Appalachian project along bioregional management lines.

⁂

A "double bottleneck effect" (population contraction) followed by excessive inbreeding has been suggested for two populations of African cheetahs by the authors of a study reported in the January *Proceedings of the National Academy of Sciences* (Vol. 84, No. 2). Researchers in Kenya, the United States and Great Britain postulate two major cheetah population bottlenecks – the primary event happening 10,000 to 12,000 years ago during the late Pleistocene period, the second, during the last century. Current studies found sperm abnormalities in the east African cheetah as severe as those found earlier in its southern relative. If the double bottleneck hypothesis is correct, the authors propose that captive crossbreeding programs using east and south African animals together might improve the cheetah's genetic profile and chance for survival.

⁂

The January issue of *Agricultural Research* reports that Pioneer elms have been grown from protoplasts (single cells with their walls removed) in Delaware, Ohio by the U.S. Agriculture Department's Ag Research Service there. The Pioneer elm is a new European-Asian hybrid that is resistant to Dutch elm disease. Agricultural researchers plan to fuse protoplasts from the Pioneer elm and the more susceptible American elm, in a procedure that would combine the genes of two species that would not breed by normal means. The process takes four to six months to produce a tiny elm plant with roots, but the four Pioneer elm trees thus produced are now about three feet tall and, according to the report, "may be the first woody plants grown using the protoplast method."

⁂

"Managers of reserves are faced with the challenge of preserving species diversity; counterintuitively, the best policy to prevent long-term change is to allow short-term change." This is the intriguing subtitle to Roger Lewin's Research News section in the Nov. 28, 1986 issue of *Science*; the title is "In Ecology, Change Brings Stability."

The problem is summarized in the following quote:

"The question for park managers and conservationists, therefore, is how to act in the face of change. If a reserve were immense in size, then no action would probably be the best action, because natural species declines in one area would probably be compensated for by species booms in another. But, as was noted by a constant refrain at the New York meeting ("Conservation 2100," a Fairfield Osborn Symposium at Rockefeller University, New York, Oct. 20-30, 1986), most reserves are going to be too small and fragmented to be maintained without the loss of species."

The article quotes Brian Walker of the Commonwealth Science and Industry Research Organization, in Canberra, Australia; "We will have to learn to compensate for the changes that will inevitably occur. We will have to learn how to manipulate the systems in the directions we want them to go, but we don't know enough about them yet to be able to do that."

⁂

Interpretive Views, edited by Gary Machlis of the NPS/CPSU at University of Idaho, provides special insights to the philosophies that currently guide interpretation in the National Park Service. In sharing their opinions on evaluating interpretation, most of the two dozen authors of this volume had to confront and then describe what they thought interpretation was all about. For the reader interested in the vocation – the rationale for interpretation – there is much to learn from these pages. NPS Director Mott calls the volume "a welcome addition the the growing body of professional literature dealing with evaluating interpretation" and urges readers to join the professional debate this volume is designed to stimulate. The 179-page softcover book may be had for $9.95 from NPCA, Books, 1015 31st St., N.W., Washington DC 20007.

⁂

From Bruce Moorhead, NPS research biologist at Olympic NP, comes an article by Olen Paul Matthews of the University of Idaho, "Who Owns Wildlife?", published in the *Wildlife Society Bulletin* (14:459-65, 1986). The article discusses wildlife "ownership," federal vs. state powers, the role of legislation and courts, and the limits of shared management. "I think," writes Moorhead, "that it clarifies many basic issues to those of us with wildlife protection involvements who are not lawyers."

⁂

Yet another review, this one sharply critical, of Alston Chase's *Playing God in Yellowstone* appears in the February issue of *Bioscience* (Vol. 37 No. 2, pp. 133-4). Written by Duncan T. Patten of Arizona State University's Center for Environmental Studies, the review recommends that the book be read by park and resource managers "with a critical eye and a rein on emotions." With all its weaknesses, Patten says, the book sends an important message: namely, that "we cannot assume any area once modified by man will ever be pristine again, and we should not manage it as such. If we do, we may lose both endangered species and critical habitats."

⁂

From the Water Resources Division, Fort Collins, comes word that the latest issue of *Virginia Journal of Natural Resources Law* contains an excellent article on critical issues involved in the management and protection of wilderness areas. "Keeping Wilderness Areas Wild: Legal Tools for Management" by Gregory W. Edwards (Vol. 6, No. 1, Fall, 1986, pp. 101-141) compares management practices and philosophies of the National Park Service, Forest Service, Bureau of Land Management and Fish and Wildlife Service. It discusses four major threats to designated wilderness areas and outlines the legal tools available to meet those dangers: mineral development, recreational use, transboundary threats, and inappropriate management practices. Finally, the author suggests some future directions for wilderness management and protection.

⁂

John Morgan, Assistant Professor of Geography and Environmental Planning at Towson State University, sends word of two recent articles that he and Fred Kuss (Department of Recreation, University of Maryland) recently coauthored. The following publications are available as reprints:

Morgan, John M. III, and Kuss, Fred R. 1986. Soil loss as a measure of carrying capacity in recreation environments. *Environmental Management* 10(2): 255-270.

Kuss, Fred R., and Morgan, John M. III. 1986. A first alternative for estimating the physical carrying capacities of natural areas for recreation. *Environmental Management* 10 (2): 255-262.

Reprints are available by writing to John Morgan, Department of Georgraphy and Environmental Planning, Towson State University, Linthicum Hall Room 30, Baltimore, Maryland 21204.

⁂

regional highlights

Pacific Northwest

A workshop on "Ecosystems Management in Parks and Wilderness", sponsored by NPS, USFS, and University of Washington, is being held at the College of Forest Resources' Pack Forest near Mount Rainier April 6-10. The workshop, limited in attendance to 30 participants, is designed to identify major issues associated with ecosystem management: likely impacts related to insularity, the role of planning and the legal system, and opportunities for mitigation via cooperative ventures. Outputs from the workshop will include a synthesis report, available in early 1988, and a technical proceedings. Attendees are experts in a variety of disciplinary and interdisciplinary fields, including managers of park and wildnerness areas. Park Service coordination is being provided by Jim Agee and Darryll Johnson of the NPS/CPSU at the University of Washington.

* * *

A multidisciplinary peer review of Crater Lake stream research was conducted in Corvallis, OR, on Feb. 26, to determine whether there exists any obvious alternative natural source that might account for the elevated nitrate levels found in a caldera wall spring that empties into Crater Lake below Rim Village. The high nitrate levels were found by Stan Gregory of the Oregon State University Department of Fisheries and Wildlife during research contracted by the National Park Service. The verdict of the review group was that no such natural source exists. The group recommended that all sewage be removed from the Crater Lake Rim.

North Atlantic

The North Atlantic Region held its first workshop on Science in Northeast National Parks March 30-31, 1987 on the campus of the University of Massachusetts in Amherst. A report of this meeting will appear in the Summer issue.

* * *

Howard Ginsberg (Rutgers/NPS Cooperative Research Unit) is entering his second year of research on Lyme disease. This phase of study will include tick/spirochete distributions at Acadia NP, Saint-Gaudens NHP, Minute Man NHS, Saratoga NHP, Cape Cod NS, Morristown NHP, Delaware Water Gap NRA, Fire Island NS, Gateway NRA, Shenandoah NP, Assateague Island NS and Cape Lookout NS. Howard presented a summary of his work most recently at the annual meeting of the U.S. Public Health Service Environmental Sanitation group in Atlanta in February.

* * *

The status and management of piping plover nesting sites at Cape Cod NS has been the subject of study and subsequent discussions between USFWS, Natural Heritage Program (MA) and the Service. The FWS is recommending predator control within Cape Cod NS to maximize fledgling success.

* * *

The article on field investigations of nearshore sediment transport problems, promised for this issue by Dr. James R. Allen, will appear in the Summer issue of *Park Science*. The studies are being conducted at Fire Island and at Riis Park in Gateway NRA.

Alaska Region

Results from a series of long-term moose studies in Denali have started appearing in print. Kenneth Risenhoover authored "Winter Activity Patterns of Moose in Interior Alaska" in *Journal of Wildlife Management* 50 (4) and "Intraspecific Variation in Moose Preference for Willows" in Plant-Herbivore Interactions. Proc. Fourth Willdland Shrub Symp., U.S. For. Serv. Intermountain Res. Sta. Gen. Tech. Rep. INT-222. James Peek, Victor Van Ballenberghe and Dale Miquelle wrote "Intensity of Interactions between Rutting Bull Moose in Central Alaska" in *Journal of Mammology* 67 (2). James MacCracken and Victor Van Ballenberghe prepared "Age-and Sex-related Differences in Fecal Pellet Dimensions of Moose" in *Journal of Wildlife Management* 51 (2).

* * *

The first publication of ongoing raptor projects in Denali NP by Karen Laing, entitled "Food Habits and Breeding Biology of Merlins in Denali National Park, Alaska" appears in *Raptor Research* 19 (2/3).

* * *

Ongoing studies of the Denali caribou herd have resulted in several publications. Rodney D. Boertje is author of three: "An Energy Model For Adult Female Caribou of the Denali Herd, Alaska" in *Journal of Range Management* 38 (5); "Seasonal Activity of the Denali Caribou Herd, Alaska" in *Rangifer* 5 (2); and "Seasonal Diets of the Denali Caribou Herd, Alaska" in *Artic* 37 (2). Francis J. Singer compiled "History of Caribou and Wolves in Denali National Park and Preserve" in Research/Resources Management Report AR-11.

* * *

Other recent publications relating to Alaskan parks are "Evaluation of Bear-Resistant Food Containers for Backpackers" by John Dalle-Molle, Michael A. Coffey and Harold W. Werner, in *Proceedings* – National Wilderness Research Conference: Current Research, General Technical Report INT-212, Intermountain Research Station, Ogden, UT, and "The Arrigetch Peaks Region of the Central Books Range, Alaska: Ecosystems and Human Use" by David J. Cooper in the above proceedings. Two additional recent publications by Cooper on his studies at Gates of the Arctic are "White Spruce Above and Beyond Treeline in the Arrigetch Peaks Region, Brooks Range, Alaska" in *Arctic* 39 (3) and "Arctic-alpine Tundra Vegetation of the Arrigetch Creek Valley, Brooks Range, Alaska" in *Phytocoenologia* 14 (4).

Rocky Mountain Region

John Varley, research administrator at Yellowstone NP, has announced reassignment of Norm Bishop from assistant chief of interpretation to a writing job with the park's research branch. Bishop will be engaged in translating research into "laymanese" for such projects as the park's wolf recovery program.

"I'll by trying to make the research information more available to the public," Bishop said. He indicated the raw material for his new job is formidable. In the north Yellowstone elk winter range alone there are 40 new research projects underway.

Western Region

Vol. I No. 2 of Western Region's "Resource Notes" (see **Park Science** Regional Highlights Winter 1987 issue, page 14) includes an extensive bibliography of publications that have been produced by Redwood NP staff, an article on oak woodland management in Redwood NP by Neil Sugihara and Lois Reed, and the flooding history of alluvial terraces in the park, by Mary Ann Medej.

* * *

Recent publications out of Sequoia and Kings Canyon include the following:

Parsons, David and Thomas Stohlgren. 1986. Long term chaparral research in Sequoia National Park. In Proceedings of the Chaparral Ecosystems Research Conference. California Water Resources Center, University of California Report No. 62. Pages 107-114; presents an overview of the ecosystem based research program in the low elevation chaparral zone of Sequoia. The project, which is funded primarily out of the Acid Precipitation Program, provides an integrated, long term look at ecosystem properties in this important community type.

Parsons, David and Patricia Haggerty. 1986. Scientific research in Sequoia and Kings Canyon National Parks: an annotated bibliography update 1980-1986. USDI National Park Service, San Francisco, CA 51 pages; provides annotated listing of all scientific reports and publications relating to SEKI published since 1980. It contains 183 entries. It updates an earlier bibliography published in 1980.

Stohlgren, Thomas and David Parsons. 1986. Vegetation and soil recovery in wilderness campsites closed to visitor use. Environmental Management 10[1]: 375-380; presents data on the recovery of soils and vegetation in subalpine campsites when they are closed to use. Recovery is so slow that a rest/rotation system appears impractical in such locations.

In addition the following papers were published in the **Proceedings of the Wilderness Research Conference.** USDA Forest Service Gen. Tech. Report INT 212 published last summer.

Parsons, David. Campsite impact data as a basis for determining wilderness use capacities. Presents the methods and rationale behind the development of backcountry use limits in SEKI.

Graber, David. Conflicts between wilderness users and black bears in the Sierra Nevada National Parks; reviews data on interactions and conflicts between backcountry users and black bears in Sequoia, Kings Canyon and Yosemite.

Stohlgren, Thomas. Variation of vegetation and soil characteristics within wilderness campsites; documents differences in plant species composition and soil properties along a use gradient from the central core to periphery of campsites.

* * *

Ecological Monographs, 56(4), 1986, pp. 327-34, journal of the Ecological Society of America, carries an article by Charles van Riper III and Sandra G. van Riper, M. Lee Goff, and Marshall Laird on "The Epizootiology and Ecological Significance of Malaria in Hawaiian Land Birds." Laboratory and field experiments conducted on the island of Hawaii from 1977 to 1980 established that avain malaria, which probably did not reach epizootic proportions on Hawaii until after 1920, have had a negative impact on the population dynamics of the native forest birds and today is a major limiting factor. In response, a number of native bird species have developed immunogenetic and behavioral responses that reduce the impact of the para-

site on host populations. Van Riper III heads the NPS/CPSU at U/Cal, Davis.

* * *

Gary E. Davis, research marine biologist at Channel Islands NP, assumed presidency of the American Academy of Underwater Sciences in Tallahassee in November 1986. Organized in 1977, the Academy is dedicated to the advancement and practice of scientific diving, and involves disciplines ranging from archaeology and geology to biology and oceanography. It provides for exchange of information and safe conduct of underwater scientific research and education through annual symposia and a nationwide workshop series. Its diving manual is the accepted standard for the community.

* * *

From Christine Schoenwald-Cox, research scientist with the NPS/CPSU at U/Cal/Davis, comes word of a growing bibliography on conservation biology in general, covering 100 to 120 journals. "We're moving backward in time," she said, "to the origin of these journals, and hope soon to make the bibliography available, with updates, to NPS managers and scientists who must operate away from major libraries."

The information will be made available through printouts and duplicate diskettes, probably for a nominal fee. The bibliography is being built without NPS time or expense, using U/Cal/Davis student volunteer help, Schonewald-Cox said.

Mid-Atlantic Region

The New River Gorge National River is sponsoring the Sixth Annual New River Symposium, April 9-11, at Appalachian State University in Boone, NC. Papers will be presented on current scientific research and on the natural and cultural history of the New River Region.

* * *

Assateague Island National Seashore is sponsoring a Research Symposium, April 3, at the University of Maryland East Shore Campus, Princess Anne, MD. Papers will be presented on a variety of natural history research topics.

* * *

The first two reports from a Regional River Recreation research program are now available from Chief Scientist John Karish. The reports are "New River Gorge National River: Analysis of Legislation and Legal Foundations for Establishing Carrying Capacity" and "New River Gorge National River: A Narrative History of its Designation as part of the National Park System." Both are by University of Minnesota researchers Steve Simpson and Leo McAvoy. Also available from John is a report titled "A Rare Vascular Plant Survey of the New River Gorge National River" by the West Virginia Natural Heritage Program

* * *

Regional Scientist Jeff Marion reports the availability of two new publications. "Environmental Impact Management in the Boundary Waters Canoe Area Wilderness" by Marion and Toivo Sober, describes the history of management actions implemented by the Forest Service to reduce resource impacts in the nation's most highly used wildnerness. Also described is a new campsite rehabilitation program for campsites currently in use to restore natural conditions and prevent impacts from reaching unacceptable levels. This paper will appear in the March issue of the *Northern Journal of Applied Forestry.* "Recreational Impact Assessment and Monitoring Systems: Past, Present, and Future" by Marion and Dave Cole, traces the history of impact monitoring systems, describes the systems currently available, and discusses areas of current refinement. Copies of both papers are available from Jeff Marion, Star Route 38, Milford, PA 18337.

Panel Reviews Sequoia Fire Management Program

At the request of Western Regional Director Howard Chapman, a panel of seven scientists familiar with either giant sequoia ecosystems or fire ecology conducted a review of the giant sequoia fire management program in the Sierran parks this past summer. The panel, chaired by Dr. Norman Christensen of Duke University, was asked to review the scientific basis and planning and operational procedures, and evaluate the adequacy of the monitoring program and research data base associated with the prescribed burning program.

The review, which started as an effort to fine tune an operational program that is commonly referred to as a model effort, became politicized when outside concerns were raised regarding the acceptability of fire scars and bark char created by prescribed burns. This conflict of ecological as opposed to basically aesthetic objectives led to much spirited discussion. An open review of the program, held at the Giant Forest Visitors Center, included a full day field trip through recently burned as well as unburned areas. It attracted more than 75 persons, including representatives of many conservation organizations. The public review was followed by site visits by Director William P. Mott.

The final panel report is expected momentarily. Briefing for the Director will be scheduled, followed by a decision on future management and research activities. National Parks Magazine will feature an article and evaluation of the program in their first issue of 1987.

Other panel members include Dr. Ron Wakimoto (U. Montana), Dr. Joe McBride (UC Berkeley), Dr. Phil Rundel (UCLA), Mr. Lin Cotton (independent landscape architect, Berkeley), Dr. Thomas Harvey (San Jose State University), and Dr. Robert Martin (UC Berkeley).

Water Resources Division

New Approaches to Monitoring Aquatic Ecosystems is the title of a published symposium by ASTM Committee E-47 on Biological Effects and Environmental Fate and by the Ecological Society of America, edited by Terence P. Boyle of the NPS Water Resources Division. Among the 13 papers included are "A Review of the Crater Lake Limnological Programs," by Gary L. Larson of the NPS/CPSU at Oregon State University, and "Monitoring and Quality Assurance Procedures for the Study of Remote Watershed Ecosystems," by Robert Stottlemyer, research scientist at the NPS Great Lakes Area Research Studies Unit, Michigan Tech University, Houghton, MI.

* * *

For a good overview of key water issues, the following recent titles are recommended by the Water Resources Division: *America's Water: Current Trends and Emerging Issues,* by Edwin H. Clark II and Philip C. Metzger; *Our National Wetland Heritage: A protection Guidebook,* by Dr. Jon A. Kusler; and two books by Terry L. Anderson, *Water Rights: Scarce Resource Allocation, Bureaucracy, and the Environment,* and *Water Crisis: ending the Policy Drought.*

revegetation notes

By Robert Kleinmann, William Fink and Sam Kunkle

Field experiments are underway at the Friendship Hill National Historic Site in southwestern Pennsylvania to test the effectiveness of an artificial wetland in reducing water pollution. Acid mine drainage has drastically degraded water quality in a small stream flowing through the historic site. No fish or aquatic insects exist in the highly acidic stream, and riparian vegetation has been killed where stream overflow has occurred. Because some wetland systems have been found to mitigate acid pollution, an experiment was designed whereby an artificial wetland would be constructed and the affected stream water diverted through it in controlled quantities and at controlled flow rates.

Toward this end, plot studies were conducted during 1985-86 on a variety of plant species to determine which ones could 1) survive at pH 2.6, the average pH of the stream, and 2) reduce acidity and concentrations of sulfate and metals. Successful plants included peat moss *(Sphagnum recurvem),* cattail Typha latifolia), and hardstem bullrush *(Scirpus acutus).* Field-testing of the wetland plants began in the fall of 1986 with completion of a prototype artificial wetland of approximately 0.15 hectare. Testing will continue throughout 1987. Water quality monitoring conducted above, within, and below the wetland will evaluate pH, acidity, conductivity, calcium, sulfates, and metals. If the wetland vegetation is successful in improving water quality in the stream, a larger, full-scale wetland of approximately 2 hectares will be established.

* * *

Kleinman is with the Bureau of Mines, Pittsburgh Research Center, P.O. Box 18070, Pittsburgh, PA 15236, (412) 675-6555; Fink is at Friendship Hill Nat'l Historic Site, RD #1, Box 149A, Point Marion, PA 15474, (412) 329-5512; Kunkle is with the NPS Water Resources Div., Fort Collins, CO 80521, (303) 491-7857.

research notes

The University of California's *NRS Transect* (Vol. 5, No. 1) asks on p. 8, "Would you like to do research on Santa Cruz Island?" The Nature Conservancy and the Santa Barbara Museum of Natural History will help by providing grants of up to $20,000 for research projects that address questions related to terrestrial and freshwater flora and fauna, geology, and ecology of the Island. For more information, including a list of high priority research topics, contact: Santa Cruz Island Project Director, The Nature Conservancy, 213 Stearns Wharf, Santa Barbara, CA 93101 (805) 962-9111, or Director, Santa Barbara Museum of Natural History, 2559 Puesta del Sol Rd., Santa Barbara, CA 93105, (805) 682-4711.

NPS Scientists Involved In Wilderness Congress

Two of the six major topic areas to be covered in the Fourth World Wilderness Congress Sept. 11-18, 1987 in Fort Collins, Colo., are co-chaired by National Park Service scientists. Dave Parsons, research biologist at Sequoia-Kings Canyon NPs is co-leader of the Acid Rain Impacts on Wilderness, Parks and Nature Reserves section. Bill Gregg, co-chairman of the US-Man and the Biosphere project for the U.S. Department of the Interior, will serve with Stanley Krugman of the U.S. Department of Agriculture to head up the section on the MAB Program: Conservation in Sustaining Society.

The other four areas to be addressed are Population and Environmental Stress, Management and Protection of Oceanic-Marine Resources, Use of Wilderness for Personal Growth, Therapy and Education, and Management of Park and Wilderness Reserves.

Speakers from many countries will be heard; workshops will provide for detailed discussion of such issues as non-governmental organizations, ethics and philosophy, environmental finance and development, conservation policy and law, and "Alaska: A Conservation Case Study," among others. As chairman of the World Commission on Environment and Development, the Prime Minister of Norway will present the Commission's final report prior to its debate in the UN General Assembly. Agenda topics include biological diversity, the role of multinational corporations, endangered species, wildlife and wildlands research and management, and the role of indigenous peoples.

Pre-Congress educational opportunities are available in August and September through the International School of Forestry and Natural Resources, Colorado State University.

Modified Elk 'Cocktail' Lowers Knockout Risk

Redwood NP has been experimenting with a mixture of ketamine and xylazine (Rompun) to immobilize Roosevelt elk. Park staff, working in conjunction with Humboldt State University professor Richard Golightly, have successfully immobilized nearly 40 elk for research and management purposes. The effects of the immobilizing cocktail are reversed with yohimbine hydrochloride. Average down time per animal is less than an hour; average reversal time under four minutes.

The ketamine/rompun cocktail and reversal with yohimbine has proven to be an effective alternative to the use of drugs like M99, which is extremely dangerous in cases of accidental human exposure and has special registration requirements with the Drug Enforcement Administration (DEA).

Another three-day workshop on wildlife immobilization and capture was held in early April and more are contemplated in the future. The classes, put on by Redwood NP with Humboldt State University and the California Department of Fish and Game, are designed to fulfill NPS training requirements (except for the OJT) for registration with DEA to use controlled substances in wildlife research and management. Cost of the class is $87.50. For more information on the elk mobilization methodology and/or the wildlife workshops, contact Terry Hofstra, NPS fish and wildlife ecologist, Redwood NP, 1125 16th St., Arcata, CA 95521 (707)822-7611.

meetings of interest

1987

August 18-Sept. 11, 21st INTERNATIONAL SEMINAR ON NATIONAL PARKS AND OTHER PROTECTED AREAS, beginning in Calgary, Alberta, Canada, and moving to appropriate field locations that will include a variety of ecosystems – tundra, montane forests, rain forests, grasslands, arid lands, coastal and marine areas, concluding in San Jose, Costa Rica. A technical and professional course to examine policies, administration, planning and other aspects of national parks and other protected areas; sponsored by the National Park Service and the University of Michigan School of Natural Resources. Contact: Hugh Bell Muller, Director; International Seminars on NPs, U/Mich School of Natural Resources, Ann Arbor, MI 48109; (313) 763-4029.

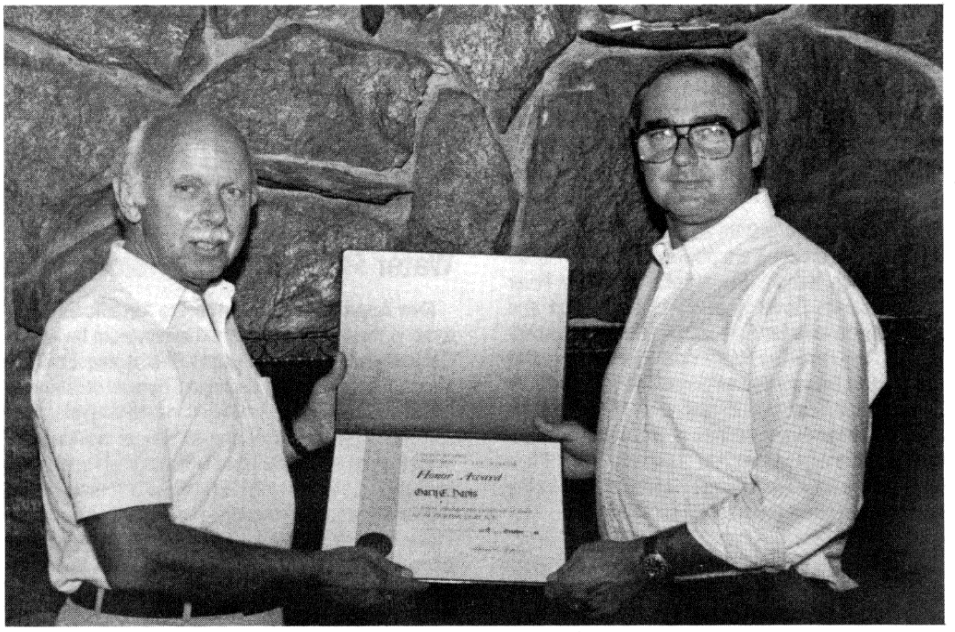
September 11-18, FOURTH WORLD WILDERNESS CONGRESS will meet in Estes Park, Colo., to address "Worldwide Conservation: A Call for a New Initiative." Contact: 4th World Wilderness Congress, International Leadership Foundation, Colorado State University, Fort Collins, CO 80523. (303) 491-5804.

November 1-5, NATIONAL INTERPRETERS WORKSHOP, including an Interpretive Research Symposium and an Interpretive Management Institute, sponsored by the Association of Interpretive Naturalists and the Western Interpreters Association, in St. Louis, Missouri. Contact: Lisa Brochu, 1987 National Interpreters Workshop, 504 Falls Ave., Lodi, CA 95240; (209) 334-4390.

1988

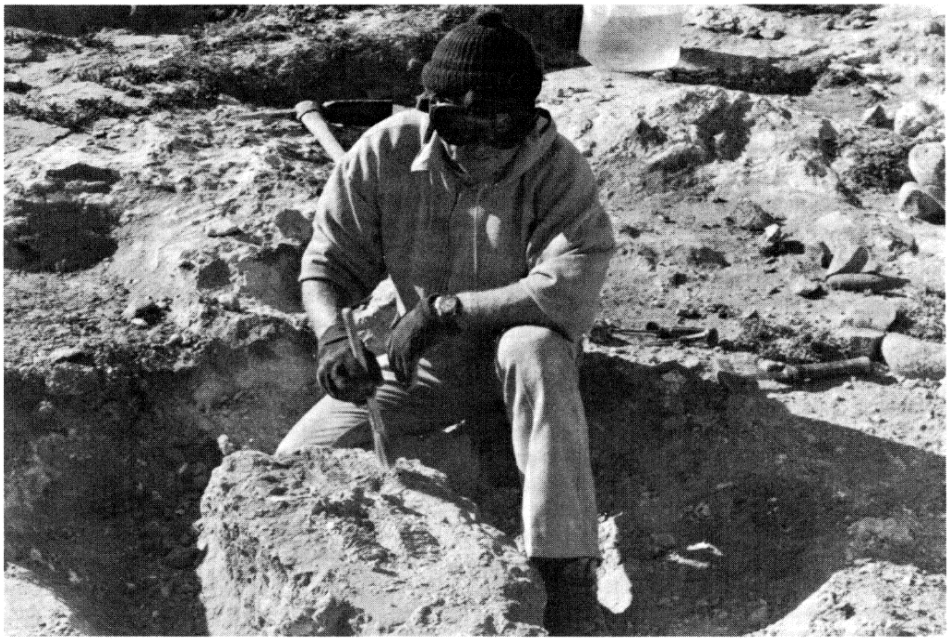
April 20-23 INTERNATIONAL SYMPOSIUM ON VANDALISM: RESEARCH, PREVENTION AND SOCIAL POLICY. Sponsored by USDA Forest Service and the University of Washington Institute for Environmental Studies. Call for abstracts of papers, presentations and posters issued in March 1987, with a June 1, 1987 deadline. Contacts: Dr. Chris Christensen, USFS, Pacific Northwest Research Station, 4043 Roosevelt Way, N.E., Seattle, WA 98105, (206) 442-7846; and Polly Dyer, Institute of Environmental Studies, U of WA, Seattle, WA 98195.

Gary Davis Earns Superior Service Award



Research marine biologist Gary E. Davis *(right) was presented with a Department of the Interior Honor Award for Superior Service by Western Regional Director Howard H. Chapman at a recent superintendents conference. Channel Islands NP Supt. William H. Ehorn announced the award, granted in recognition of Davis' devotion to duty and outstanding contributions to the park's natural resources management program. In 1980, when Channel Islands NP was established, Davis began development of a long-term ecological monitoring program including regular checkups of more than 450 plants and animals such as giant kelp, Torrey pines, lobsters, sea lions, pelicans, and foxes to indicate the health of park ecosystems. An important aspect is the cooperative interaction of local, state, and federal agencies and university scientists from as far away as Florida, Georgia, and Hawaii. Its original design and comprehensive scope make this program a model for long-term natural resource monitoring in national parks.*

San Miguel Island Yields Pygmy Mammoth Skull



The intact skull *of a pygmy mammoth is shown here being excavated from San Miguel Island in early November. The expedition was overseen by Channel Islands NP archaeologist Don Morris, with excavation under the direction of paleontologist Dr. Robert Gray, Santa Barbara City College. The skull is one of fewer than 10 that have been recovered from this small Pleistocene elephant, remains of which have been found on most of the Channel Islands. Dr. Gray observed that this specimen, while that of a mature adult, appeared to be exceptionally small. Because the specimen was exposed to damage from continuing erosion, and also because of its rarity, a decision was reached to collect the skull this year, according to Channel Islands NP Supt. William H. Ehorn. Dr. Gray is completing preparation of the material at Santa Barbara City College, after which a decision will be made about possible display of the remains.*

Imagine This Guy – Using His GIS Data!

Dr. Jan (Jan Van Wagtendonk, Yosemite NP) called the other day to get some information from his GIS data base. Imagine this guy – actually wanting to use his data! Anyway, his query was kind of interesting, and since it resulted in some information never before seen by the eyes of man (or woman), I thought I'd report it and the process we used to get it.

It seems the park is involved in some kind of a discussion with the state of California over the stocking of high country lakes. I'm not up on the details, but the issue, for the moment, has come down to the number of lakes within the park in various size classes, for example, the number of lakes less than and the number of lakes greater than one acre and one hectare, respectively.

Well, it so happens the Yosemite GIS data base contains all the park's lakes. Wasn't that lucky! They had been digitized (actually, scanned) a couple of years earlier, before anybody knew anything about this particular application. All we had to do was ask the GIS to count and sort the lakes by size. In the interests of candor and general enlightenment, I think it instructive to report how, using SAGIS, one of our GIS software systems, the process actually worked.

1. We first ran polygon overlay to separate the lakes inside the park from those outside the park. The park data file is quadsheet based and so all quads (except Hetch Hetchy) contain lakes both inside and outside the park boundary. The park only wanted counts on lakes *inside* its boundary.
2. Next we ran an area-computation program to compute areas and sent the results (which also included perimeters) to a file (rather than to the terminal's screen or an attached printer).
3. We then sorted the areas-file in ascending order.
4. We sent the sorted file to our PC for dressing up and permanent storage, printed it (Fig. 1), and sent the printed list to the park for classifying and counting the occurrences however they wished.
5. We plotted the lakes and visually inspected for ones that straddle quad sheet boundaries (there are six) to eliminate double counting of single lakes.

Experienced GIS users will probably scoff at this application. After all, it's monothematic, doesn't use sophisticated modeling and predictive techniques, and, except for the simple (-minded) polygon overlay, doesn't even combine themes and look at various combinations of intersections. That's okay. Here are some simple and useful results that would be very difficult and time-consuming to produce any other way (if it could be done at all). Nobody had ever seen this information before, and I was intrigued. Maybe you are too.

Harvey Fleet, *Chief, Digital Cartography Branch, GIS Division, NPS Denver Service Center.*

Fig. 1. Lake Acreages and Perimeters, Lake Eleanor Quad.

Acreage	Perimeter (mi.)
.19	.063
.32	.089
.36	.091
.38	.091
.48	.107
.51	.119
.59	.115
.71	.130
.77	.135
.89	.153
.94	.151
.95	.150
.98	.143
1.01	.159
1.07	.179
1.21	.163
1.56	.234
2.10	.250
2.11	.216
3.48	.302
4.30	.419
4.54	.440
4.65	.499
7.07	.459
14.18	.594
21.85	.773
67.68	1.231

Supt. Joe Kennedy *assists in the banding and radio-tagging of a great-horned owl in Dinosaur National Monument. Mark Schroeder, Natural Resource Specialist Trainee, live-captured several owls to assess relocation of great-horned owls from the vicinity of peregrine falcon hacking boxes as an alternative to shooting them. For further information contact Mark Schroeder, Resources Biologist, Grand Teton NP.*

Streamside Management Proceedings

Persons interested in the Proceedings of the interdisciplinary symposium on Streamside Management, Riparian Wildlife, and Forestry Interactions held in February at the University of Washington, should send letters of interest to the College of Forest Resources, AR-10, University of Washington, Seattle, WA 98195, Attention Office of Publications. Order forms and price information will be sent. The symposium featured comparisons of communities in managed and unmanaged riparian systems and the social and economic factors that influence riparian forest management decisions.

'The Visitor Experience' – What Do We Really Mean?

By Jill Cowley and Richard Schreyer

An NPS planner and a park superintendent are discussing an undeveloped area of a hypothetical park. "Well," says the superintendent, "as for the visitor experience, we were thinking of providing an access trail to the lower ruin. If we take it around this way they'll experience the enclosure of the canyon . . . and perhaps we need to think about handicapped access . . ." "Let me see" the planner says, "I think we could keep it at 5 percent along here . . . and we could enhance the interpretive experience by putting in some waysides . . ."

Four years later, at the same site, a visitor approaches the park ranger: "I used to come here when all the signs weren't here – it's all different now. Are there any other ruins I can go to where it's not so developed?" A visitor study shows that 60 percent of visitors to the site were dissatisfied with the changes, and 20 percent said they would go somewhere else. The staff and planners tried to enhance the visitor experience – what went wrong for the 60 percent?

The value of planning and managing for visitor experiences is becoming more and more widely realized, and the term "the visitor experience" is coming into wide use in NPS documents. There is increasing concern within applied recreation research for the quality of the park visit, what visitors are getting out of their visit, and whether or not they are satisfied. So we plan in terms of the visitor experience. But what does this really mean? Are we talking about the experience offered by the resource or the internal experience of the visitors – what they are thinking and feeling? Park resources, in addition to their intrinsic value, provide elements to be experienced, for example the expansiveness of a view or the fine masonry work of a prehistoric pueblo. Resources also provide settings for experiences. As NPS employees we see it as our responsibility to identify and provide access to those resources we think visitors will enjoy the most. We determine to a large degree what visitors experience.

How the resources are experienced also is important. The kind of internal experience visitors want – how they want to feel within the resource – determines to a large extent how they want to experience the resource. For example, if visitors want to feel challenged and independent rather than safe and guided, they may prefer to experience the resources in a setting with fewer facilities, without structured interpretation, and with a more difficult trail. When we presume to provide for visitors, we need to be aware of what internal experiences they want.

How do we plan and manage for these kinds of experiences, which may seem too personal, too individualistic, or too intangible to deal with? Because activities are easier to understand and visualize, we may find ourselves describing an experience in terms of an activity, for example, a "backpacking experience." However, people interested in the same activity (e.g. hiking) may be seeking very different experiences (e.g. relaxation vs. risk and discovery) and therefore desire very different kinds of settings. Planning would be more effective if we could describe experiences in a way more manageable than considering each person as unique, but without oversimplifying the diversity groupings. Is it possible to categorize visitor experiences in the same way we do activities?

Visitor preference research completed at Bandelier National Monument during the summer of 1984 indicates that it is possible to categorize a range of experiences at cultural resource sites.

More background on the experience range concept and more details on this study can be found in "The Role of Visitor Preference Information in the Planning, Design and Management of Archeological Resource Areas in the National Parks," a Masters thesis completed by Jill Cowley in January 1987, at Utah State University.

The purpose of this research was (1) to determine the range of visitor preferences for experiences and, in order to give planners and managers an indication of how to provide for these experiences, (2) to see if visitors associated different facilities and interpretive media with the different experiences. A total of 395 visitors completed on-site questionnaires which asked (1) how important were certain experiences to you on this trip? and (2) how much did different types of facilities or interpretive media add to or detract from your overall experience?

Because Bandelier is a park rich in archeological resources, experiences such as "to understand how the prehistoric people who used to live here compare with other Indian groups in the southwest" and "to enjoy the special way the ruins make me feel" were included as well as experiences such as "to take risks" and "to feel my independence." The list of facilities included signs, toilets, picnic tables, and handicapped access. The list of interpretive media included both personal media (e.g. ranger-guided walks and cultural demonstrations) and impersonal media (e.g. waysides and trailguides).

Factor analysis was used to determine which experiences visitors grouped together, that is, wanted at the same time. Four groupings were found:

I INTERPRETATION – visitors wanting this group rated highly experiences such as:
- "finding out facts and figures"
- "comparing with other cultures"
- "to feel like the prehistoric people"

SR STRESS-RELEASE
e.g. – "to relieve my tensions"
- "for tranquility"

SF SELF-FULFILLMENT
e.g. – "to develop my skills and abilities"
- "to increase my self-worth"

S SOCIAL
e.g. – "to be with the other members of my group"

It was possible for visitors to rate more than one of these groups or types of experiences as important. Although there were visitors who wanted all the possible combinations, most visitors wanted one of six combinations:

I Interpretation
I/S Interp/Social
I/S/SR Interp/Social/Stress-release
ALL Interp/Social/Stress-release/Self-fulfillment
SR/SF Stress-release/Self-fulfillment
SR Stress-release

These combinations can be arranged along a continuum from an emphasis on interpretation to an emphasis on stress-release, with mixtures in between. According to the results, when visitors want one of these combinations of experiences, they are also looking for certain facilities and interpretive media, as shown in Table 1.

Research results such as these indicate the range of desired experiences which, ideally, are provided for either within the park or within the region. They also suggest how opportunities and settings can be structured to enhance specific experiences. For example, if an area is being planned to include a self-guided interpretive trail which will encourage those seeking a stress-release experience to be involved with interpretation, any development or facilities would be put at the trailhead and not at the archeological site itself, since facilities at the site is very unpopular with this group.

Even more useful than knowing these kinds of preferences is knowing "critical preferences," that is, knowing what facilities and media can "make or break" an experience. Critical preferences were not directly tested for in this study, but this can be done in future

Table 1 – Summary of Visitor Preferences

Experience Preference Range					
I Interpretation	I/S Interp/ Social	I/S/SR Interp/ Social/ Stress-release	All All four	SR/SF Stress-release/ Self-fulfillment	SR Stress-release
FACILITIES					
Added to a lot*	trail & road signs	trail & road signs	— (no strong responses)	trail signs	—	—
Detracted from a lot	—	—	—	—	—	facilities at the archeological site
INTERP. MEDIA						
Added to a lot	self or ranger-guided trails, demonstrations	As in I plus visitor center & slide talks	self-guided (trailguide or wayside)			
Detracted from a lot	—	—	—	—	—	—

research. Critical preferences may make enough difference to change a visitor's behavior, as was the case in the scenario at the beginning of this article. We can return to the planning stage and "replay" the conversation between the planner and superintendent as it might have been if they had had access to research results on the range of visitor experiences:

"Well, as for the visitor experience," the superintendent says, "we know that out of the range of experiences wanted by visitors, the intermediate one – where they want less structured interpretation – is the one we really haven't planned for in the park. We were thinking that this area might be a good one . . ." "Now, for that experience," the planner continues, "we'd need to plan a trail, one that's good for self-guided interpretation – no facilities, though." "And the resources in this area can't take a lot of visitation, which will fit in with the kind of numbers we would expect for that experience . . ."

Basic research can be used to test the experience categories described here. Important questions are: do these categories represent real people? Do the categories apply to all types of parks or just archeological parks? Park-specific visitor surveys completed during planning can determine how many visitors to that park want which type of experiences. The results can be combined with resource information to determine how and where to best provide for the different experiences. In the absence of research, planners and managers can continue to use their observations of visitors and existing preference studies to develop a range of experience types. The more accurate and realistic our understanding of the range of experience preferences, the more effective and responsive we can be in providing opportunities for enriching park visits.

Cowley is a Landscape Architect at the NPS Denver Service Center; Schreyer is a Professor in the Utah State University Department of Forest Resources at Logan, Utah.

Equipment Alternatives for Using SAGIS

By Harvey Fleet

As more and more of you out there become interested in GIS and, in particular, in running SAGIS, the Geographic Information System we use in our Digital Cartography Program here in Denver, I am frequently asked for advice and recommendations on appropriate equipment. In this article I will attempt to explain hardware alternatives, as I see them, as of January, 1987.

Before I do so, however, let me emphasize that this discussion is only relevant for those of you who anticipate using SAGIS, either as a possibility or a certainty. If you are interested in GIS but have no interest in SAGIS, then you probably should not read further.

Alternatives 1, 2a and 2b assume you are going to tie into SAGIS running on a remote host computer located away from your park. I know that many of you are reluctant to go this route, because of time-sharing and telephone costs, relatively low-speed, poor quality communication lines, and a feeling that somehow you are not "close" to your data (they are not in the same room with you).

A couple of pending developments may cause you to reconsider this set of alternatives, at least as an interim measure: (i) we have acquired a mainframe Prime computer here in Denver; your remote use of this machine will cost you nothing. (The bad news: we will only be able to accommodate about 8 to 12 remote users at one time.) (ii) We intend on becoming a GEONET node, which means most of you can dial us up via a local, or perhaps *nearly* local, telephone call. This will both eliminate long distance telephone charges and provide high quality communications lines. Data transmission rates will still be relatively slow (1200 baud), but 2400 baud may be available a little later. Your costs for using the GEONET network will either be nothing or nominal (a few tens of dollars per month at the most).

Alternative 3 describes an attractive stand-alone configuration you may wish to consider.

Terminals

To display mapped information from SAGIS at a computer terminal, you need either a Tektronix device or Tektronix emulation running on some other device, usually a PC. While you *can* use SAGIS without Tektronix compatibility, I do not recommend it, because you are essentially working blind – you have no way to see, to plot, what you are working with. In addition, you have no way to zoom in, and you cannot use the crosshairs, which are required for a whole variety of operations. Here are some alternative possibilities:

1. Acquire a new Tektronix terminal, which range in price from about $4,000 to $25,000. The $4,000 terminal has most of the features of the high-end terminals, except it has lower resolution (640 x 480) and is considerable slower. In general, this alternative gives the best performance and greatest ease of use.

2a. Acquire monochrome Tektronix emulation for your PC. Monochrome emulators run in the $100 to $200 range. In Denver we use VTEK, which is available from Scientific Endeavors, Route 4, Box 79, Kingston, TN 37763 (615-376-4146) at a cost of $150. These emulators will enable you to get basic displays, use crosshairs, and get hardcopy plots, depending on your plotter or printer. They will open to you a limited range of SAGIS's display capabilities but the *full* range of SAGIS's analytical capabilities. If you want only to try out SAGIS and see what it can do, and whether it would be useful to you, this is probably a good place to start. Before ordering any emulator, call the manufacturer to make sure it will run on your PC.

2b. Acquire color Tektronix emulation for your PC/XT or PC/AT. There are several color Tektronix emulators around, but the type I recommend should provide "4107" emulation, which includes much more than simply line color recognition and selection. Only one package that I know of does this, and it seems to provide about 90 percent of the capabilities of the native Tektronix device, although it is considerably more difficult to use. It is called TGRAF07, and a list of retail outlets in your area can be obtained from Grafpoint, 4340 Stevens Creek Blvd., San Jose, CA 95129 (408-249-7951). TGRAF07 sells for $995. To use TGRAF07 you must have an EGA graphics board (about $440) and accompanying monitor (about $580). Check with the manufacturer or dealer before you buy. If you already have an AT or equivalent and want to try or use SAGIS, this alternative, for about $1,000 to $2,000, is quite attractive. It will give you access to about 90 percent of SAGIS's interactive display capabilities and all of SAGIS's analytical capabilities.

3. Acquire a 32-bit coprocessor board for your PC, which will allow you to run SAGIS locally, i.e., in stand-alone mode, without dialing up a remote computer. These boards run between $3,000 and $5,000 and, essentially, divide your PC into two separate, but communicating machines: the standard PC and a co-resident mainframe. SAGIS runs on the mainframe board under UNIX and sends its output to the standard PC board for display. Therefore, the PC also must be equipped with either a monochrome Tektronix emulator or a color Tektronix emulator, as described in 2a and 2b, respectively, above. Alternatively, you could send the SAGIS output from the 32-bit board to an external, stand-alone Tektronix terminal.

Any way you do it, you should have at least 30 megabytes of fixed storage (for data) in your PC. (You may also consider adding additional, removable, external mass storage. Bernoulli cartridges, at about $2,000 a throw, are attractive considerations.)

Printers, Plotters

Most people, quite correctly, want some kind of hardcopy capability, preferably in color. What you can get will in large measure depend on the kind of terminal and software emulation you use. The situation is very complicated; there are many options, and I do not know all of them. I can, however, give some guidance, as follows: a dot matrix printer, which you may already have attached to your PC, can probably be used, *if your Tektronix emulation software supports it.* A dot matrix printer will give satisfactory draft-quality black-and-white plots.

Pen plotters, which run between $1,000 and $10,000 will give very high quality, scaled plots. They are unexcelled for line-work, but not so good for solid-color fill (i.e., filling in regions of the map with a solid color), and completely unable to produce solid fill using repeating symbols. SAGIS supports several pen plotters, and your Tektronix terminal emulator may also provide its own pen plotter support.

Ink-jet plotters, which run between $1,000 and $7,000, can also give high quality, scaled plots. They are unexcelled for solid-color fill, but not as good as pen plotters for line-work. They are very easy to use, because all you have to do is push a button and the contents of your display screen will be dumped to them. I like them because of this feature, and because "what you see (on the terminal's screen) is what you get (on the plotter)." In this price range, scaling all but the smallest plots (8.5″ x 11″) requires that you piece together individual sections. It's tedious, but it gets the job done, and done well. I recommend ink-jet plotters as the best overall compromise (unless all you want to plot is line-work). The make and model you will get will depend on the terminal or terminal emulator you are going to use.

Digitizing Tablets

Most people want their own capability to enter data into their GIS data bases. You will need a digitizing tablet to do this. Digitizing tablets run between $1,000 and $6,000, depending on size and features. I recommend that their active surfaces be no smaller than two feet by three feet in size. Necessary features include scale translation, variable output format, RS232 communications, and 0.001 inch resolution and accuracy. WARNING! Do not attempt to use a digitizing table to build an entire GIS data base. This is a complex, tedious, labor-intensive, and very technically and administratively demanding operation. I strongly urge you to use the digitizing tablet only for minor updates and additions to your *existing* data base, rather than for bulk, production digitizing.

Fleet is Chief, Digital Cartography Branch, GIS Division, National Park Service.

Black Bear Species/Area Relationships Studied at Rocky Mountain NP

By Henry E. McCutchen

Our research team is conducting a study on a black bear population at Rocky Mountain National Park (ROMO) that exhibits considerable difference from similar situations in other parks.

When the park was established in 1915, grizzly bears and black bears were present in low numbers. The grizzly became extinct here by the late 1920s. Historical records indicate that the black bear population increased to some degree over the years, but the species has never been common. In the past, the black bear population in the park has been estimated at 30 to 40 animals.

The park, 265,000 acres in size, received 2,523,122 total visits in 1986. This is relatively high visitor use, ranking 7th in visits among the 48 National Parks. Some national parks with high visitation and black bears have high numbers of bear problems. Yosemite, Sequoia, Kings Canyon, and Great Smokies are examples. However, ROMO has never been an area noted for many bear problems. Records of bear incidents in the park from 1959 to 1983 totaled 133, with an average of about 5 per year. This is low compared to Sequoia and Kings Canyon NPs, which between 1959 and 1976 had a total of 3,968 bear incidents for an average of 220 per year.

An exception occurred at ROMO in 1984. That year bear incidents reached a record of 90. Most of these occurred in the backcountry. This was unexpected because the park has an intensive backcountry management program that encourages trash pack out and clean camps.

The depredations of bears at backcountry sites in the park in 1984 caused even more intensive management to be undertaken. This included backcountry closures, an intensive bear information program, increased backcountry patrols, enforcement of food handling and storage rules, and a bear capture and transplant effort. Bear reports and sightings during this period indicated that at least two sub-adult males were the cause of the depredations. One of these was captured and transplanted out of the area.

Because of the events, a number of questions were raised about the bears in the park, such as: What caused the increased number of bear problems? Considering the apparent low densities of bears, what level of management or control could be tolerated by the population without risk? Can bear depredations be predicted by some environmental parameter such as dry weather? What is the population density and ecology of the bears in the park, and what is the relation of those parameters to the heavy backcountry visitation and outside pressures?

To answer these questions, in 1985 a 3-5 year research program was initiated. The study area is a 120 square mile section located in the southeastern third of the park. The area contained the sites where most of the bear depredations occurred in 1984. It also receives the highest front and backcountry use, and has the most intensive urban and suburban development along the boundary.

Bears are difficult to census because they are solitary and occupy forested habitat. Thus, research methods involved an intensive capture, marking recapture and radio collaring effort throughout the study area. When research was initiated, we assumed that the bear population was static and at carrying capacity. It was anticipated that the area would have a "core population" of adults with stable home ranges with surplus sub-adults migrating or dispersing outside the park.

To date, however, the research results (tentative) have not supported the original assumptions. After an intensive effort, only 6 resident bears have been captured in the study area. The average density is low with only 1 bear per 20 square miles. These data sharply contrast with a black bear density of 1 bear per 3-5 square miles found by another study in south central Colorado.

Among the bears captured in the study at ROMO was a single adult female. The rest were sub-adult males and females. An adult male has been observed in the area during breeding season, but has not yet been captured. It appears that his usual home range is outside of the study area. Unfortunately this age structure exhibits the classic symptoms of an exploited population. It appears that mortality is so heavy upon adult bears in the study area that a stable population and land tenure system cannot be established. Sub-adult bears appear to be immigrating into the area from outside. This scenario was not expected in a national park and International Biosphere Reserve. Thus, the research has raised a new question. A combination of small park size, habitat encroachment, and human predation most likely caused the extirpation of two of the park's wide-ranging carnivores, the wolf and grizzly bear. Is the park's black bear population now at risk from similar pressures?

The research has not yet identified the underlying causes of the 1984 bear problems. The source of the depredating sub-adult males of 1984 could have been offspring of the single adult female or siblings which immigrated here from an outside area. The future offspring of the females in the area will be monitored to determine their behavior. Also, weather records are being correlated with bear behavior to determine if poor food years are related to bear incidents.

During the field seasons of 1985 and 1986, the research team was equipped and ready, not only to capture and mark bears, but to respond to any backcountry depredation with a capture effort. However, these years were relatively quiet with only a few bears even being sighted by park visitors.

Some additional information obtained by the research is noteworthy. The bears in the study area are small in body size. The largest was a 3-year old male weighing 180 pounds. The adult female, cementum aged at 13 plus years, weighed only 108 pounds in 1985. The single mortality of a radio-collared bear to date was of a sub-adult male, which wandered outside of the park and was killed by a hunter.

In many parks bears are highly visible and are attracted to human use areas. At ROMO, visitor observations of bears are low. Radiotelemetry has revealed that generally the black bears are secretive and avoid areas of human use and developments. This type of behavior can be considered a "model" for park bears. For example, one 4-year old female has an exclusive home range in one of the most heavily visited areas of the park. Her range includes a ski area, several trails, several picnic grounds and a good portion of the heavily used Trail Ridge Road. Although there are numerous refuse cans and dumpsters scattered throughout the area, the little bear does not visit them. She is seldom observed in the park at all. Instead, she feeds on small patches of natural food and stays out of sight of roads and trails. At the time of her initial capture in the summer of 1985, she weighed 78 pounds. When she was examined in her den during the winter of 1985-1986, she weighed only 54 pounds.

The use of skilled biological technicians *pays off on the black bear project at Rocky Mountain National Park. Janice Gruttadauria poses with a bear which she snared and tranquilized in the park. Janice, previously employed with the Pennsylvania Game Commission, has several hundred bear captures to her credit.*

Small size is a curious *phenomenon of the black bears at Rocky Mountain National Park. Biological technicians Bob Stark and Shelly Ament heft a tranquilized 3-year-old.*

This is considered to be an extreme weight loss. It is considered curious that this small bear's strategy for survival would be to risk starvation in the den and feed upon natural foods rather then forage upon readily available, high energy, human refuse within her home range.

The cause or causes of low bear densities in the study area are now being investigated. Four major factors appear to be involved. First, the Town of Estes Park is located adjacent to the eastern park boundary and increasing numbers of subdivisions, summer homes, condominiums, dude ranches and convention centers are being constructed here. These are usurping bear travel corridors and habitat. Second, there is apparent heavy hunting pressure on bears adjacent to the park. The only mortality of a park radio-collared bear to date was from outside hunting. Third, there is heavy visitor use of a concentrated network of roads and trails in the study area, which may cause disturbance to the bears. Many trails pass through productive patches of bear habitat. Fourth, in the park, forest fires have been suppressed for about 70 years. This has caused an increase in mature stands of forest and a decrease in patches of earlier stages of plant succession. The research is indicating that patches of earlier plant succession are important to the bears. Evaluation of the first two factors is important because they relate to the park's susceptibility in becoming an "ecological island" for the bears.

Some mitigation of the risk of hunting pressure on the park bears has occurred recently. Information on the low bear densities in the park was provided to the Colorado State Division of Wildlife in 1986 during its consideration of bear hunting regulations. Subsequently, the State placed more restrictions and lower limits on bear hunting in areas adjacent to the park.

Also, a comprehensive fire management program is being planned for the park. When it is implemented, the reestablishment of the fire regime will create a mosaic of vegetation that includes early successional stages. An important by-product of this program will be bear habitat improvement.

It could be argued that the park's bears are where management wants them; that is, with low densities and creating few problems with property or with visitors. However, the NPS must also meet its preservation mandate for all species, including black bears. Thus, at ROMO, a new bear study is being selected in the park for additional censusing. This area contains more mesic forests, receives less visitor use, and is adjacent to large tracts of National Forest Land. A comparison of bear densities and population parameters between the two areas should clarify the status and trend of the park bear population.

For ROMO, the black bear shows potential as an important "indicator species" for ecosystem health. It is hoped that the research will show the park is large enough, and contains sufficient habitat and bear numbers for a viable population.

Ultimately the research should provide park managers with information from which to develop bear/visitor management programs. Further, the study should have implications in regard to species/area size, bear habitat/fire management programs and bear management programs in other National Parks.

McCutchen is a Research Scientist at Rocky Mountain NP.

In Search of a Better Feral Pig Trap: A Modification in Trap Door Designs

By William M. Brock

In Hawaii Volcanoes National Park, feral pig control has taken top priority in resource management efforts. At present, feral pigs are found in all habitats except for alpine stone deserts, barren lava flows and cinder fields, some arid coastal zones and urbanized areas. They occupy rain forests, mesic forests, seasonal montane forest, shrubland and open grassland habitats – in all, about 22,500 ha or 25 percent of the park.

Pig impacts are well documented in the park (Baker, 1979). They destroy understory plants in the forests and shrublands, and enhance the spread of alien plant species. Through their rooting and wallowing habits they create pockets of standing water that breed mosquitoes, a vector of avian malaria which decimates native forest birds.

Trapping is being explored as one tool in an arsenal of techniques to eliminate feral pigs. Trapping has been effective in controlling feral pigs in other areas and a variety of combinations of trap styles, door designs and tripping mechanisms have been reported in the literature (Diong, 1980). A basic trap design is a corral type (Hone and O'Grady, 1980). This design incorporates a small, permanent corral, equipped with a one-way door. Because of its size and door design, this trap permits multiple captures. The key to the multicapture effectiveness of this trap is the door design. In its simplest form, the door is merely a hinged plywood panel which swings only in one direction, permitting a pig to enter but not escape.

At Hawaii Volcanoes we have refined this traditional door design to attract animals which have become wary of traps. The door we developed utilizes a series of independently, one way swinging bars (Fig. 1). The bars swing on a rod that passes through holes drilled in the bars. These holes are drilled to close tolerance to prevent lateral movement in the bars. Space between the bars is maintained by spacer sleeves. Washers between the spacer and the bar make for smoother opening. The advantages of the bars over the traditional plywood panel door is that they provide a "visual cue" to the bait inside the trap and the pig need only move as many bars as necessary to enter. Because the bars move independently they tend to "drape" over the animal resisting the tendency for a pig to back out of the trap once the door is lifted. Slots at the bottom of the door provide a resting place for the bars and help prevent lifting and escape.

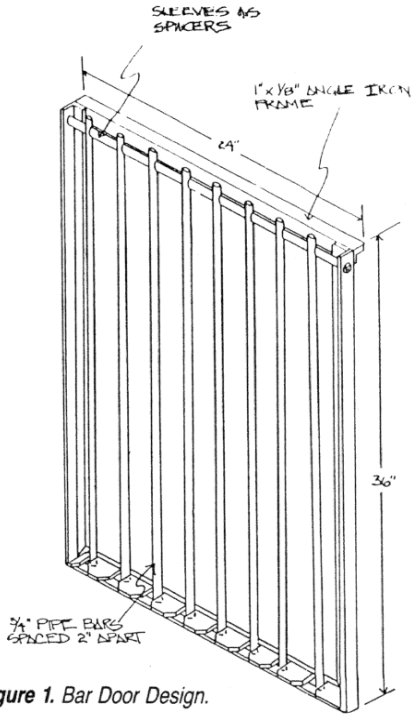


Figure 1. *Bar Door Design.*

This door has been tested successfully and is currently used strategically with other techniques to eliminate animals within control units.

* * *

Brock is a Natural Resource Specialist trainee at Hawaii Volcanoes NP.

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'411' Impresses Trackers With Her Native Skills

By Allen J. Barth

Bald eagles *(Haliaeetus leucocephalus)* in Grand Teton National Park (GTNP) are the subject of intense research by the tri-state Greater Yellowstone Ecosystem Bald Eagle Research Project in Montana, Wyoming and Idaho. In Wyoming the project is funded by NPS, USFS and the Wyoming Game and Fish Department. Dr. Al Harmata, of Montana State University, is directing the study, during which most of the nestling eagles since 1979 have been banded each year. In 1985 and 1986, a few of the eagles were equipped with transmitters to better monitor their movements, and one eagle was followed as it migrated from Wyoming, through five other states, to a wintering area in northern California.

On June 16, 1986, the Schwabacher nest was visited and two eaglets were discovered. Both were banded, various measurements taken and blood drawn for analysis. The larger, believed to be a female, was equipped with a solar-powered, backpack transmitter. Her activity was monitored several times a week as she moved about the nest, not yet mature enough to fly. She was named "411," referring to her transmitter frequency.

411 fledged on August 14 but the signal was not received until September 4, when she was located in Granite Canyon (at the south end of GTNP), 14 miles from her nest site. She left the canyon the next day and was located on August 17 6 miles east of Alpine, Wyoming where she was followed along the Snake River to Palisades Reservoir, about 30 miles from her nest.

She stayed at the reservoir, interacting with other young eagles there, until October 1. At 12:15 p.m. she "rang-up," gliding in a tight circle, letting the uplifting power of a thermal carry her. After reaching a height of more than 400 feet she began to glide southwest – the beginning of her fall migration. She headed southwest the first two days, slowly moving over ridges and valleys, gliding 2-5 miles, losing height and ringing-up to gain altitude once more. Covering 60 miles the first day and 90 the second, she had passed through parts of Idaho and Utah. The fledgling was tracked using a Park Service 4-wheel drive Chevy Luv equipped with a 2-element directional antenna. The antenna had a range of approximately 20 miles while the eagle moved over the ridges. Roads along her path enabled relatively close monitoring as she traveled, averaging 16 miles per hour.

411 moved west the next two days, across the north end of Utah into Nevada, averaging 125 miles per day. The signal was lost near Contact, Nev., but was relocated by aircraft near Winnemucca. At an altitude of 14,000 feet in a plane the range of the antenna could be increased to more than 50 miles while 411 perched, and about 100 miles while she soared over the ridges. She had changed her flight technique from flying high in thermals to staying low along the sides of ridges where updrafts allowed her to soar. She rarely needed to flap her wings.

The following two days she headed northwest from the Winnemucca area, across the Black Rock Desert, through the extreme northeast end of California and on to southern Oregon. There she discovered the Thompson Valley Reservoir, with a large population of American coot, intermixed with many duck species, providing an abundant food supply. She stayed at the reservoir for two weeks.

The first couple of days seemed to be difficult. At Palisades Reservoir she utilized the abundant source of dead fish; but at Thompson Valley Reservoir she was faced with live avian prey. At first she scavenged off remains that the adult eagles left behind. She fiercely defended carcasses against persistent ravens, going so far as to chase a raven down for taking a small piece of meat. After three days of scavenging, she successfully caught a coot. She seemed to watch the adults as they hunted, observing the easy meals they gained. She soon caught a coot a day, occasionally taking a duck – usually green-winged teal.

411 frequently soared around the area, venturing only 5-7 miles before returning to the reservoir. On October 18 – the opening of Oregon's waterfowl season – she departed the reservoir for a longer period, not returning until the following morning. The adult bald eagles had also departed the area and were seen less frequently after hunting began.

When she returned to the reservoir a close sighting revealed that the transmitter was too tight, due to her unexpected great increase in body size. She continued to fly with no difficulty however. The straps seemed to be giving her some discomfort so capture plans were made.

Six #2 double long spring leg-hold traps heavily padded with foam rubber and tape were used to capture her. The solar transmitter was removed and replaced with a tail-mount transmitter. Immediately after being placed on the ground she gained flight and flew about a half mile, landing in a snag. She was in excellent physical condition, very fat and full of energy. At 1:40 p.m. she rang-up and headed south, flying 12 miles in under an hour, the farthest she had traveled since her arrival 2 weeks earlier. It was likely the handling had affected her.

The following morning 411 turned southwest. The signal was lost that afternoon and searches the rest of the day and into the following morning turned up no signal. A plane was chartered out of Klamath Falls to conduct an aerial search. She was located on Gerber Reservoir, only 40 miles south of her location the previous morning. She stayed on the reservoir for two days before traveling on. Her flights were very irregular with frequent direction changes. After three days of traveling in a generally southerly direction, averaging only 30-40 miles per day, she arrived at Reservoir F near Canby, California. Like Thompson Valley Reservoir, Reservoir F was teeming with coot and waterfowl.

Arrangements were made with the U.S. Forest Service Wildlife Biologist, George Studinski, to continue monitoring 411. It was believed she would stay until early winter, then move near Tule Lake National Wildlife Refuge, 50 miles northwest of Reservoir F. The refuge winters a great number of bald eagles.

Previous sightings and recoveries of banded bald eagles led researchers to speculate that young eagles traveled along major waterways during their migrations. 411 seemed to key in on other signals that directed her flight. She covered many miles, in a relatively direct line of travel, by use of air currents which minimized her energy use. She was even able to locate herself in an area known to winter many eagles, without having made the trip before and by doing so alone. As research continues on bald eagles much can be learned to assure their survival and success.

Barth has a BS degree from the University Wisconsin – Stevens Point in Wildlife Management. He is currently working with the Wyoming GYE Bald Eagle Working Team.

Fat and sassy *after a couple of months on her own, this bald eagle fledgling (christened "411" for her radio transmitter frequency) readies herself for take-off after having her solar-powered backpack transmitter replaced by more comfortable tail-mount equipment.*

History, Mythology, and Limnology of Lake Crescent, Olympic NP

By Bryan E. Pierce

Editor's note: Following is a synopsis of a limnological study that introduces, explores, and in some cases explodes the local myths that surround many such deep lakes as Crescent. These extra-limnological observations are included as source material for park interpreters.

Lake Crescent in Olympic National Park is one of very few large oligotrophic (unproductive) coastal lakes in western North America. Its pristine natural beauty makes it an important tourist attraction and its clear waters are home to endemic forms of extraordinarily large rainbow trout (*Salmo gairdneri irideus,* to 20 lbs.) and cutthroat trout (*Salmo clarki clarki,* to 12 pounds). Myths often accompany large, deep lakes and Lake Crescent is no exception. Discrepancies in this mythology exist in local opinion, as well as in the popular and scientific literature; however, many of these conflicting beliefs were examined and clarified in a recent study of the lake, which was undertaken to enhance and facilitate the management of this fragile limnological system.

Lake Crescent is situated between the coastal foothills and the main range of the Olympic Mountains at an elevation of 176.5m (579 feet). Although numerous inholdings exist along the shores, this ecosystem remains largely natural. One and a half meters (60 inches) of rain annually (Walken 1955) coupled with a mean annual temperature of 5.9°C (42.6°F) places the lake in the Transition Zone (e.g., climax western hemlock and western red cedar forests). The watershed is predominately Canadian Zone.

The Lake Crescent area was covered most recently by Vancouver Island origin cordilleran glaciers during the Vashon Stade of the Late Wisconsin (Fraser) Glaciation (Alley & Chatwin 1979). Final deglaciation probably occurred prior to 13,000 BP which suggests that the lake is 1-2 thousand years older than is stated in most literature (i.e., Scheffer 1935, Hagen 1961).

Lake cross-sections from echosounder transects show the typical steep sided U-shape of a glaciated valley. Eocene basalt is found on the northeast shore of Lake Crescent while the balance of the basin consists of suboceanic origin sandstone, shale, and conglomerate (Tabor 1975). There is a longstanding belief that the lake is actually a drowned portion of the adjacent Soleduck River channel, but the presence of a long natural bedrock ramp across the west end of the lake where such a channel should continue refutes this hypothesis.

Just after deglaciation, Lake Crescent included the present sister lake, Lake Sutherland, and emptied to the east through Indian Creek and the Elwha River drainage. A landslide along the northeastern shore, the scar of which is still clearly visible, divided the two lakes and forced the current Lake Crescent to rise approximately 16.8m (55 feet) before spilling into its new north-flowing outlet, the Lyre River. Anadromous fish passage up this outlet is currently blocked by a natural barrier falls about 2.4km (1.5 miles) downstream from the lake. Some literature (Kemmerer et al. 1923, Mausolf 1969) suggests that this block (a log jam, cascade, narrow raceway and 3m overhanging falls) was passable during recorded time; however, there is no evidence to support this suggestion. The unusual upstream migratory behavior of fry of the outlet spawning trout (Pierce 1984a) appears to be an adaptation to the long-term isolating effects of this barrier to seaward migration.

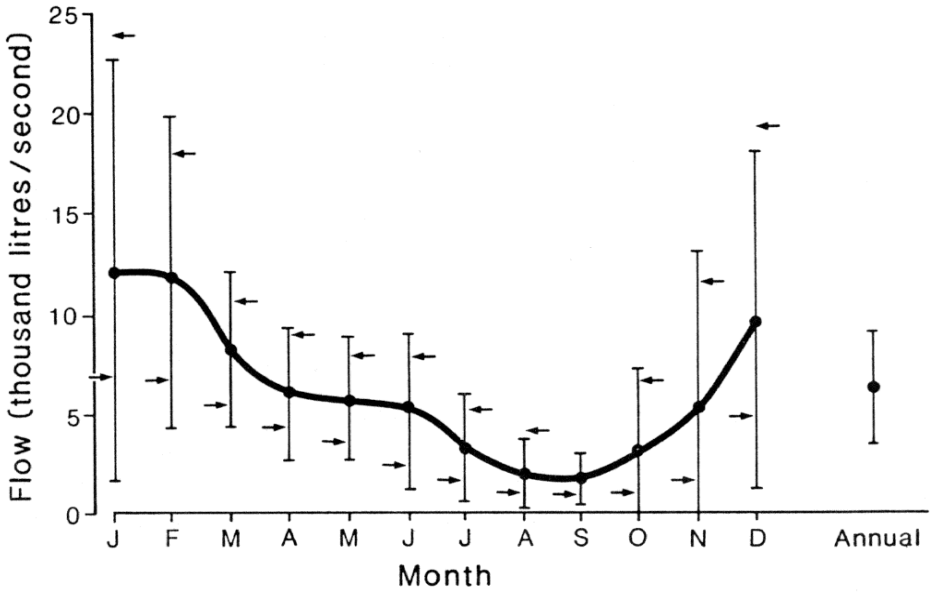

Fig. 1. *Outlet mean monthly flows, 1917-1927 (Walken 1955). Bars indicate 95 percent confidence intervals about the grand mean; arrows show the actual maximum and minimum mean monthly flows measured during the period.*

Proposals to remove or bypass this obstacle are unjustified, as such a modification would greatly alter the composition of the Lake Crescent fish community while the low productivity of the system would contribute little to anadromous fish runs.

The Lake Crescent watershed encompasses about 12,000 hectares (30,000 acres), of which 1,800 hectares (4,650 acres) constitutes the lake itself. About 8.7 percent of the terrestrial watershed lies outside Olympic NP and is potentially susceptible to logging or other modification.

Barnes Creek is the major tributary to the lake with 37.7 percent of the watershed area, of which 11.6 percent lies outside the National Park. Other tributaries are relatively minor and may dry up during summer, especially along the northern shore. These small streams are subject to short, intense winter floods.

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Location: 123 50′ West Longitude, 48 6′ North Latitude R. 8-10 W., T. 30 N.
Age: 13000 years
Substrate: primarily sandstone, shale and conglomerate. Northeast shore: Eocene basalt.
Elevation: 176.5m (579 feet)
Rainfall: 1.5m (60 inches)
Mean Annual Temperature: 5.9 C (42.6 F)
Biome: Lake Crescent – Transition Zone. Watershed – Canadian Zone
Anadromous fish passage: blocked
Lake Area: 1880 hectares (4650 acres)
Watershed Area: 12100 hectares (30000 acres) (including the lake)
Watershed Outside Olympic National Park: 8.7% of total
Barnes Creek Watershed: 37.7% of total
Lake Level Fluctuations: 0.94m (37 inches) in 1984
Depth: 190m (624 feet) in mid-western basin
Mean Depth (Z): 101m (332 feet)
Volume: 1,906,000,000 cubic meters (1,545,000 acre feet)
Shoreline Length: 35.2 km (21.9 miles)
Shoreline Development: 2.29
Water Exchange Rate: 9.8 years per cycle
Trophic Status: Oligotrophic
Trophic State Index: 18
Stratification Pattern: warm monomictic
Secchi Disc Visibility: 15-18.3m (49-60 feet)
Oxygenation: fully oxygenated at all levels all year
pH: 7.9 (1976); 7.3 (1982)
Alkalinity (as HCO3): 49.5 mg/1
Limiting Nutrient: nitrate

Table 1. *Vital statistics of Lake Crescent, Olympic NP, Washington.*

Lake Crescent

Continued from page 21

Maximum flows usually occur in January with minimum flows in August and September. Spring snow melt has relatively little impact on flows. Based on the 10-year mean Lyre River discharge rate and the volume of the lake basin, the flushing exchange rate is about 10 years.

During 1982 the lake level fluctuated 0.94m (37 inches). This is considered historically "normal" except in years when debris dams block the outlet causing levels to increase up to an additional meter. Past and ongoing proposals to dam the lake outlet for hydroelectric power generation would greatly exceed this gradual level fluctuation and deleteriously alter the existing macro-invertebrate communities, as well as eliminate the sole spawning grounds for the endemic rainbow trout stock.

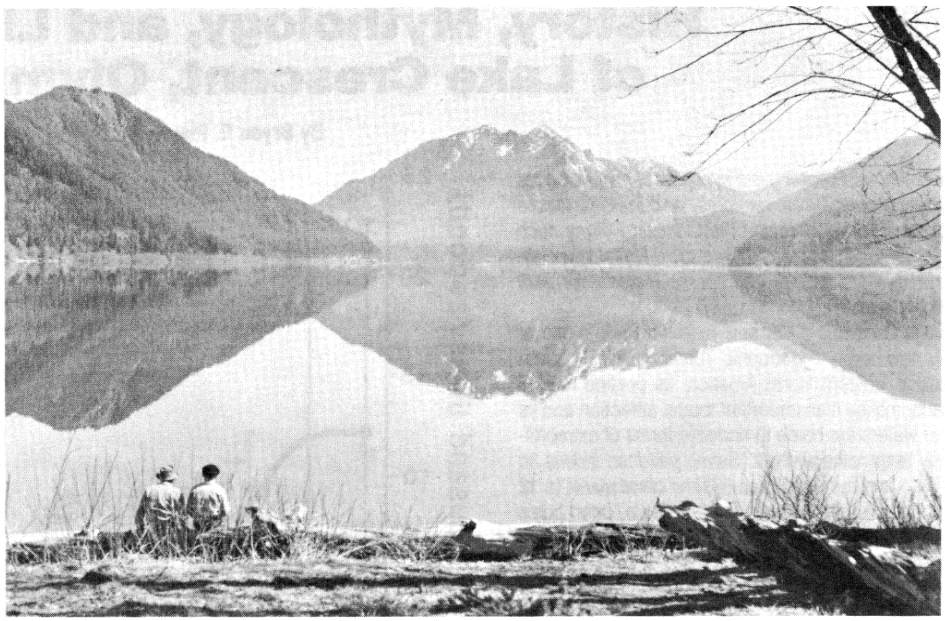
While some local residents believe Lake Crescent to be 'bottomless" it actually descends 190m (624 feet) to 13.5m (45 feet) below sea level in the middle of the western half of the lake basin (Peterson 1957, reconfirmed during the present study). The average depth is 101m (332 feet), which is remarkably deep for a coastal lake. The sharp drop-off along most of the 35.2 km (21.9 mile) shoreline of Lake Crescent results in a minimal littoral zone.

Shoreline development was relatively low (2.29) for this lake, indicating that, while the basin is elongate, the shoreline is quite straight with few large coves. A low shoreline development again reflects less potential for the development of littoral communities (Wetzel 1975). Construction of a highway and railroad grade directly adjacent to most of the lake's shore originally resulted in much timber falling into the lake, but will hinder natural rates of input in the future. With relatively little littoral habitat to support invertebrate production, it is important that new snags, which support invertebrate communities and shelter juvenile fish, be allowed to enter the lake (or be artificially introduced) to replace older degenerating logs and woody debris.

The Trophic State Index (TSI) of Carlson (1977) provides a measure of the trophic status of the lake, using Secchi disk visibility as an index of productivity. Secchi disk visibility for Lake Crescent was given as 15m (49 feet) by Kemmerer et al. (1923), as 17.5m (57 feet) during a June 1976 water quality assessment by Olympic NP, and as 18.3m (60 feet) during August 1982. The earliest readings may reflect silt input from timber harvest in the basin or higher nutrient influxes from private dwellings which were more numerous during the first half of this century than at present. The most recent Secchi disk rating yielded a TSI value of 18, an oligotrophic rating.

Assuming phytoplankton requirements of seven units of nitrate to one of phosphate (Wetzel 1975), extant values indicate that Lake Crescent is a nitrate limited system (Pierce 1984b). After destratification, both nitrate and phosphate values initially increased by a factor of approximately 2.5 in 1982 as unutilized nutrients in the hypolimnion (cold, deep water layer) became available. Nitrogenous pollutants would increase plankton production and therefore reduce the lake's normal high water clarity.

Few data exist concerning the water chemistry of Lake Crescent. Dissolved oxygen data by Kemmerer et al. (1923) indicate near-saturation levels at water depths to 175m (575 feet), the maximum depth sampled. An NPS analysis in June 1976 indicated a surface pH of 7.9 and alkalinity of 49.5mg per liter (as HCO_3). The 1982 surface pH value of 7.3 is less alkaline than the value reported in 1976. It is important that this parameter be monitored in future to detect potential acid rain effects on this relatively unbuffered water body.



Lake Crescent, *in Olympic National Park, is an important tourist attraction.*

Thermal stratification of Lake Crescent had not been studied prior to my work in 1982. Many local residents believed that the lake was permanently stratified. Depth-time isotherms obtained from March 3, 1982 to Feb. 28, 1983 proved this not to be true. The lake waters mixed in mid-winter, but quickly began to warm and stratify again in early spring. While the gradient did not meet strict requirements for a "true" metalimnion (i.e., temperature change >1°C/m), there is no doubt that stratification occurred in summer. As the winter of 1982/1983 was one of the warmest on record, it is quite likely that the destratified period is longer than most years. The temperature during mixing (initially) and of the hypolimnion (the stratum of lake water below the thermocline) during summer was 6.4°C (43.5°F). Thus, Lake Crescent may be classified as a warm monomictic lake; "warm" meaning never cooling to 4°C, and monomictic meaning one water circulation period per year.

An analysis of these limnological aspects reveals that the key features of this lake are its extreme depth, low productivity and isolation. The full impact of these combined factors has not always been recognized. For instance, attempts to introduce a run of sockeye salmon (*Oncorhynchus nerka*) to the lake (1927-1931) failed because returning adults could not pass the barrier falls (Pierce 1984b). If the physical and biological integrity of Lake Crescent is to be preserved, future management strategies must carefully consider the overall interplay of the limnological features that determine the character of this unique system.

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A new book, hot off the Roberts Rinehart presses, is *Wildlife in Transition: Man and Nature on Yellowstone's Northern Range,"* by three NPS research biologists – Don Despain, Doug Houston and Mary Meagher, and Paul Schullery, author of *The Bears of Yellowstone.* The 130-page volume sells for $6.95 in paperback, $15 in clothbound edition.

Chaparral Studies at Sequoia Provide Management Insights

By David J. Parsons

While better known for its stately giant sequoia groves and spectacular high elevation scenery, Sequoia National Park is home to the most expansive, undisturbed area of chaparral in the National Park System. Located immediately downslope from the sequoia mixed conifer forest, over 20,000 acres of chaparral are protected in the low elevation foothills of the park. Characterized by hard leaved, deep rooted, evergreen shrubs, mature, often uniform aged chaparral now covers extensive areas within the park. This highly flammable, fire adapted vegetation type presents a challenge to park managers: that is, how to restore fire to its natural role without risking damage to life, property, and the sequoia groves immediately upslope. Such decisions require considerable knowledge of past and contemporary vegetation patterns, ignition sources, fire behavior and fire effects.

Over the past decade a major research program has been directed at better understanding the ecology of the foothill zone of Sequoia NP. Since fire plays such an integral role in the foothill ecosystems, which include annual grasslands, oak savannas and hardwoods in addition to chaparral, much of this effort has been directed towards understanding the natural role of fire in the area. This includes studies of fire adaptations as well as the effects of fire and fire suppression on such ecosystem properties as plant succession, productivity and nutrient cycling. The research has been carried out as a cooperative effort between the park's research staff and Dr. Philip Rundel at UCLA (previously at UC Irvine). These studies, which for the most part have been recently completed, provide a wealth of knowledge of value to park managers and interpreters.

The dominant plant community in the foothill zone of Sequoia NP is known as chamise chaparral. Overwhelmingly dominated by a single species, the needle leaved evergreen chamise, the community does especially well on dry slopes with thin, rocky soils. Chamise is noted for its high flammability and its capacity to resprout following fire. Other locally important species include manzanitas, ceanothus and mountain mahogany. Manzanita species, which are restricted primarily to rocky ridgetops in the foothills, become relatively more common at higher elevations. Several species of Ceanothus, most of which are nitrogen fixers, are locally abundant for several decades following fire but usually die out after 40 to 50 years. Mountain mahogany is found primarily on the moister north facing slopes. Several other short lived shrub species can be found following fire or disturbance. The hot dry summers characteristic of mediterranean climate areas limit shrub growth to late winter and spring. During summer months severe water stress reduces physiological activity to low levels. Maximum growth occurs in the spring when temperatures are warm and moisture is available. Soils in the chaparral zone are characterized by sandy loams with low levels of total nitrogen and phosphorus.

While most of the foothill zone of Sequoia has not burned in at least 60 years (as far back as reliable fire history records go), and probably 80 to 100 years, it is known that chaparral is a highly fire adapted vegetation type. For example, the ability to resprout following fire, while most likely an ancestral trait not evolved under a fire regime, allows many species to quickly reestablish following burning. Other species, including many fire successional herbs are obligate seeders adapted to prolific germination following heat or exposure to charate (charcoal leachate from burned wood). The abundant growth of ephemeral herbs the first few years following fire (we found they constituted 64 percent of the total biomass one year following fire in chamise chaparral) plays an important role in sequestering nutrients so they will not be lost to erosion and leaching. Our studies of the successional dynamics of chamise chaparral following fire have documented an increasing fuel loading, surface to volume ratio, and ether extractive content, all of which increase flammability, in the decades following fire. This fits well with the general belief that chaparral is best adapted to fire at intervals between about 20 and 50 years.

Much of the Sequoia research has focused on evaluating the effect of seasonality of burning on stand recovery. Experimental burns carried out in the spring and early fall have documented a higher root crown survival and thus stand regrowth rate following more natural fall fires. On the other hand, it appears as if more intense fires cause higher mortality of chamise regardless of the time of year. Additional studies of population structure and post fire demography have documented many of the subtle effects of burning under different conditions. The development of regression equations to predict the above ground biomass of individual shrubs based on basal stem diameter and density provides a basis for determining pre-burn fuel loading as well as monitoring post-burn succession.

The management implications of the Sequoia fire research program include the ability to better predict both the short and long term effects of alternative burning strategies. Since the ultimate management goal is to restore natural fire regimes, and natural ignitions are known to have occurred primarily in the late summer and fall it follows that management burns should be conducted during those periods. On the other hand, before natural ignitions can be allowed to burn or prescribed fires can be set during the high fire danger period, it will be necessary to first assure that such ignitions will not threaten structures, safety or other resources. This requires a thorough understanding of fire behavior, the protection of boundaries and the breaking up of large areas of uniform aged brush to reestablish what is thought to be a more natural mosaic of age classes. The Parks Division of Resource Management is now in the process of developing a fire management plan to restore more natural fire regimes in the chaparral and other foothill communities. In addition to eventually allowing most lightning strikes to burn, such a plan must ultimately incorporate knowledge of lightning ignition patterns and fire spread and behavior models. This will provide at least part of the data base necessary to replace those fires that are either suppressed for safety or political reasons or would have burned into the park if not suppressed by other agencies. Unfortunately, much of the necessary data on fire history and behavior required to fully implement such a program is still lacking. In the meantime, management decisions will have to be made on the basis of the best available information.

Other benefits that have been derived at least in part from the Sequoia chaparral research program include a better understanding of the plant communities and flora of the area and the development of monitoring guidelines to assist managers in evaluating the effects of management burns. Additional spinoffs have come from the National Acid Precipitation Assessment Program study that is ongoing in Sequoia. That program has funded meteorological measurements, soil survey and chemistry work, hydrology measurements, and the establishment of permanent vegetation plots in the chaparral zone. Other research currently under way in the area includes studies of dry and wet deposition chemistry and nitrogen mineralization. This focus on multi-disciplinary, long term research promises a continued emphasis on better understanding natural ecosystem processes and thus more refined management and improved interpretive programs.

Parsons is a Research Scientist at Sequoia and King's Canyon National Parks.

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"A History of Prairie Restoration and Management at Homestead NM of America" by Gary Willson and James Stubbendieki.

"Padrie Island Kemp's Ridley Sea Turtle Update" by Donna Shaver; "Western Revegetation Programs: A Regional Roundup" by Tom Warner; "Seismic Research at Chaco Canyon" by Keith Yarborough and Kent King.

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