PARK SCIENCE

A RESOURCE MANAGEMENT BULLETIN

NATIONAL PARK SERVICE
U.S. DEPARTMENT OF THE INTERIOR

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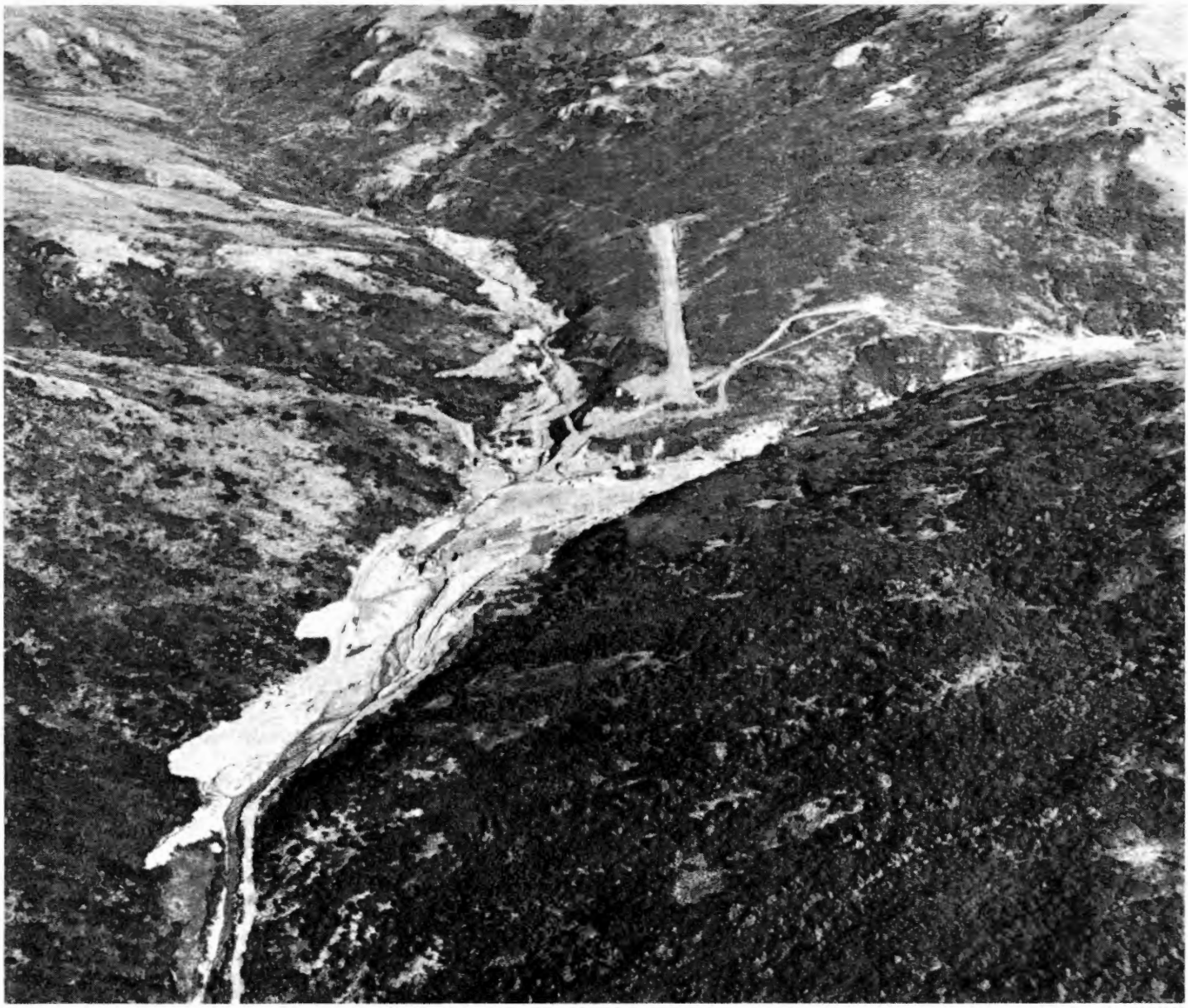

PARK SCIENCE

NATIONAL PARK SERVICE

WINTER 1986

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 Photo:
Surface disturbance associated with placer mining in the Glen Creek mining area. Tall shrub scrub cover type adjoins areas of surface disturbance in stream drainage. (NPS photo)

IT'S BEEN A LONG TIME since we carried information about how to write for these columns, and the changing nature of the manuscripts being submitted for *Park Science* publication indicates a need to rebroadcast the objectives and guidelines.

First, the subject matter: *Park Science* is dedicated to the circulation throughout the National Park Service of information about scientific research that is recently completed, on-going, or perhaps merely contemplated, but which in all cases has important *management implications*. The question in the minds of all authors should be: "What does all this contribute to better management of the area (or the System)?"

Second, the length: Because *Park Science* is limited to 24 pages, four times a year, the editorial board has decreed that only in very exceptional cases shall any article run longer than six, or at most seven, double spaced, typed manuscript pages. When longer articles come in, the editor has to decide whether to send them back for cutting by the author, to cut them herself, or to turn them down. She would prefer to expand the publication to fit all the excellent material that comes in, but alas, this is not an option. (So much excellent material was "backed up" that *Park Science* received a first-ever permission to exceed its 24-page size – this issue only.)

Third, the "art": Photos are welcome, so long as they focus on the research. Pictures taken in the field, showing research process and/or findings, are especially welcome if they come in as glossy black and white photos. We can't use color, so anything that has to be "translated" is an added expense and can always be counted on to lose a lot in the translation. Tables should be clearly typed and checked. If you have graphs, they should be submitted as "PMT's." This set of initials stands for photomechanical transfer, and it consists of a high quality, glossy rendition of your graph, done with a commercial type printing camera. It saves your parting with precious originals and makes your article (and therefore, *Park Science*) look its very best. We *like* that.

Fourth, the editorial route: Presumably, no submissions will come to the *Park Science* editorial office without clearance by the Region and whatever park is mentioned. Seldom will the Regional Director need to see your copy, but no superintendent should open the pages of *Park Science* and have an article about his or her park come as a complete surprise (let alone a rude shock). We *don't* like that. Neither do the superintendents.

That about does it. We're delighted with the response from all over the System in terms of editorial submissions. Some Regions are responding with more material than others, but every one of you is sending in *something*, and the comments from readers convince us that this way of keeping a farflung field informed and "in touch" is a good idea that is working well.

One last caveat to the scientists: Remember, *Park Science* is not a journal. Gear your presentations to the general audience, and remember that superintendents and their resource management staffs, busy and beset, want to know – right up front – how this piece of research or information is going to help them manage *their* responsibilities. Keep writing for the journals. That's part of *your* professional responsibility. But remember that you owe it to your profession to communicate outside the ranks. *Park Science* is your vehicle.

APPROXIMATE DEADLINES FOR RECEIPT OF MANUSCRIPTS

Winter issue: November 1
Spring issue: February 1
Summer issue: May 1
Fall issue: August 1

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Aerial Photos of Land Cover Types Aid Denali Mining Impact Analysis

By Steven Hunt, Budd Titlow, Ralph Root, John Dennis and Garry Waggoner

The Alaska National Interest Lands Conservation Act (ANILCA), enacted on Dec. 2, 1980, established new, and extended existing, conservation system units in Alaska managed by the National Park Service, U.S. Fish and Wildlife Service, Bureau of Land Management, and U.S. Forest Service. Among other provisions, the act expanded Mount McKinley National Park and redesignated it as Denali National Park and Preserve to take in the entire mountain massif and protect habitat for wildlife and fish populations on 6 million acres of federal lands.

Additionally, ANILCA withdrew federal lands within National Park System units from the U.S. mining laws, subject to valid existing rights; 317 such claims exist within the Kantishna Hills portion of Denali NP, north of the Alaska Range; another 151 claims are concentrated in the Dunkle Mine area of the park, south of the Alaska Range. ANILCA provided specific direction with respect to these claims by requiring a study of park and mineral resource values for both areas, including the environmental consequences of further mineral development.

In 1982, the Kantishna Hills Dunkle Mine study group, consisting of three state and four federal agencies, was created to prepare the required study report. This study group conducted field investigations in 1982 and 1983 on geology, mining history, mineral resources, water quality, fish populations and aquatic habitat, salmon spawning, historic resources, wilderness potential, recreational use, wildlife habitat, and large mammal populations, including the Denali caribou herd.

Due to the considerable potential for further mineral development to cause significant effects on the natural and human environment, the task assignment included preparation of a technically adequate EIS. The National Park Service was made the lead agency for preparing this EIS, and the Environmental Assessment Branch of the NPS Energy, Mining and Minerals Division was given responsibility for producing it. Preparation began in March 1983 and ended in December 1984.

This article describes a project initiated by the authors in 1983 to identify and map the vegetation and land cover types present in the two areas – Kantishna Hills and Dunkle Mine. The mapped vegetation and land cover types were analyzed relative to existing and future mining locations and the findings were used in the EIS analysis to evaluate alternative management options ranging from mineral development to park resource protection in both study areas. The overall purpose was to provide an adequate technical basis for analyzing environmental consequences and enhancing use of the EIS for informed decision-making.

The Kantishna Hills study area, 194,968 acres, lies near Wonder Lake in the north central portion of the park in rugged, low lying hills. The Dunkle Mine study area, 22,841 acres, lies along the park's east boundary, south of the Alaska Range near Broad Pass and east of the West Fork of the Chulitna River. (Fig. 1)

Development of Vegetation Classes. The vegetation/land cover classification system adopted for the study had to reflect the following factors and constraints:

1. The purpose of the vegetation maps was to provide quantitative data on vegetation and cover types within the study areas relative to existing and future mining locations.
2. Existing aerial photographs had to be used and no on-the-ground checking of vegetation and land cover types was possible.
3. Because of gaps in coverage, both color infrared (CIR) and black-and-white (BW) photos had to be used.
4. Calculations of the aerial extent of each mapping class had to be available within 4 weeks after the project started.
5. Project team members lacked detailed on-the-ground knowledge of vegetation types at one or both study areas.
6. Choice of mapping classes had to reflect a general approach to reduce complexity, minimize the difference between interpreters, and maximize overall accuracy.

The project team considered using an existing system (*A Preliminary Classification System for Vegetation of Alaska* by Viereck and Dyrness, revised as of 1982), but inspection of this system, plus the limiting factors listed above, led the team to develop a hybridized system that contained 15 vegetation and land cover classes and included three levels of density for forest cover and three shrub classes. After reviewing a large number of ground and low altitude 35mm color photographs and attempting to interpret them for portions of the study area, the team members found that even this system was too complex and highly detailed to permit accurate and consistent mapping. At this point the team worked out a new system with fewer classes and a more generalized approach.

The new system, with 10 classes, contained only two classes of forest, two classes of shrubs, and six other classes. These ten cover classes included:

1. **Floodplain forest:** A tall forest of both coniferous and hardwood tree species with crown cover of 25 percent or more, generally restricted to drainages within the study area.
2. **Upland forest:** A medium to low stature forest on upland sites with a total crown cover of 25 percent or more.
3. **Tall shrub scrub:** This cover type is limited to shrubs with heights exceeding 5 feet and crown cover exceeding 25 percent. It occurs from drainage bottoms to near timberline, often mixed with a lower stature, open shrubland.
4. **Low shrub scrub:** This consists primarily of low shrubs (less than 5 feet tall) and open areas covered with grasses and sedges – abundant on slopes and benches throughout the area.
5. **Alpine tundra:** This mapping unit occurs usually above 3000 feet throughout the study areas. Bare rock and soil are intermixed with a thin layer of lichens, dwarf shrubs, forbs, and grasslike plants.
6. **Floodplain barren:** Active stream floodplains where flooding occurs frequently and nonvegetated or sparsely vegetated alluvium (less than 25 percent cover) predominates.

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Table 1: Summary of Study Area Vegetation and Land Cover Types

	Study Area Vegetation Types (acres – percent)	
Class	**Kantishna Hills**	**Dunkle Mine**
Floodplain Forest	4,978 (2.6)	87 (0.4)
Upland Forest	46,792 (24.0)	1,256 (5.5)
Tall Shrub Scrub	40,500 (20.8)	11,650 (51.5)
Low Shrub Scrub	71,113 (36.5)	9,312 (40.8)
Alpine Tundra	29,752 (15.3)	57 (0.3)
Floodplain Barren	396 (0.2)	316 (1.4)
Upland Barren	158 (0.1)	—
Altered	468 (0.2)	23 (0.1)
Fire Scar	809 (0.4)	—
Water	—	139 (0.6)
Total Area	194,968 (100.0)	22,841 (100.0)

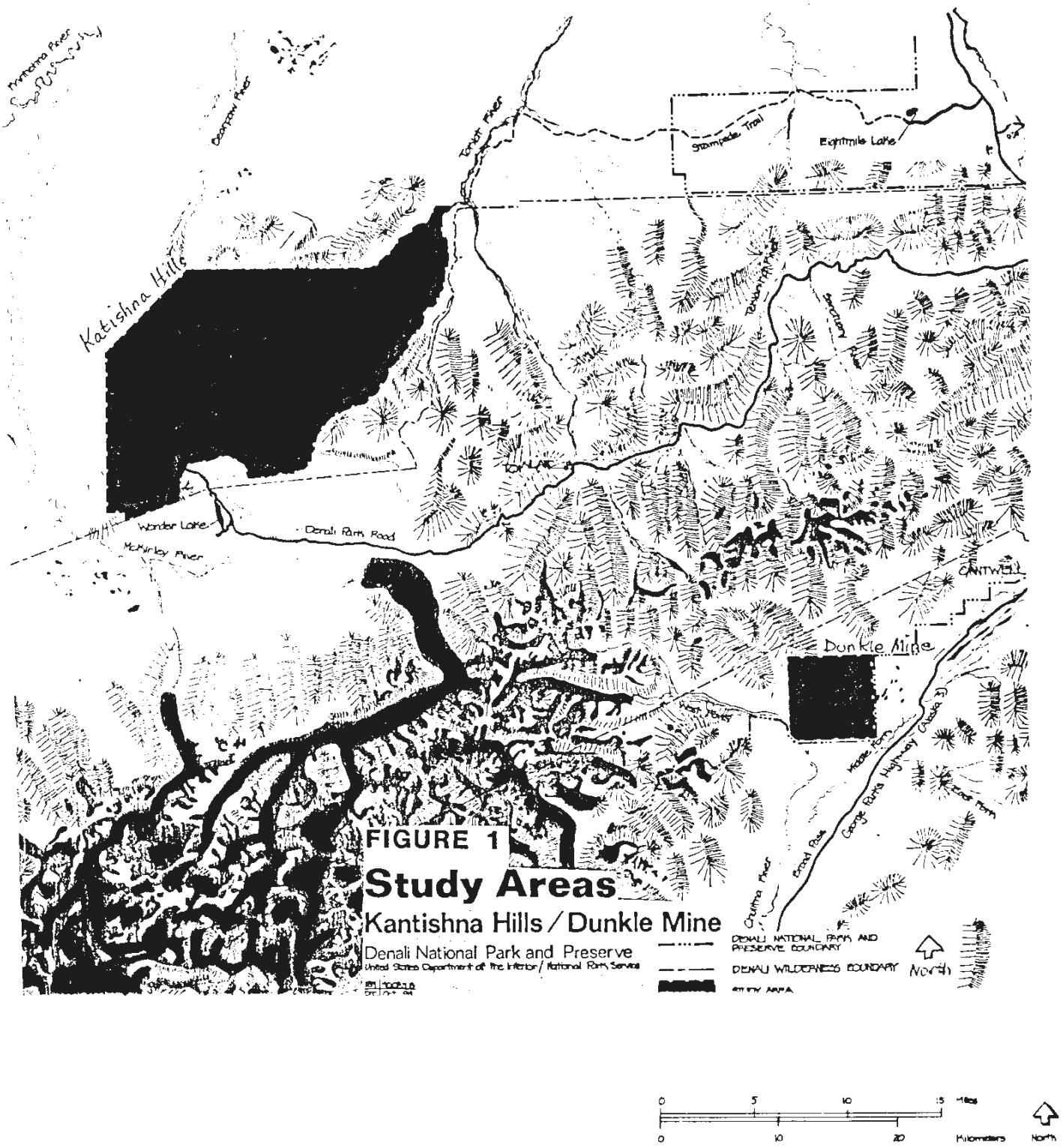

FIGURE 1
Study Areas
Kantishna Hills / Dunkle Mine
Denali National Park and Preserve
United States Department of the Interior / National Park Service

7. **Upland barren:** This includes bare rock outcrops, talus, colluvium, and bare soil (all naturally occurring) with overall cover less than 25 percent vegetation.

8. **Altered:** This mapping unit describes areas where vegetation has been stripped by human action and less than 25 percent vegetative cover is left. It is most common within floodplains along drainages where placer mining has occurred.

9. **Fire scar:** This cover type represents areas showing on the photos as recently burned, regardless of original cover types. Mapping this ephemeral type in certain locations does not imply that historic burns are limited to these areas.

This project involved three phases of data development: (1) photo interpretation, (2) transferring information to a base map, and (3) area determinations of vegetation and land cover types.

Interpretation of Aerial Photographs. Successive pairs of overlapping photos ("stereo pairs") were set up and viewed through stereoscopes, thereby creating a three dimensional model of topography and surface throughout the study area. Cover type boundaries were drawn on one photograph "member" of each stereo pair. Each completed photograph then was matched with adjoining photos to ensure consistency of interpretation. In some cases, minor adjustments were necessary to match exactly interpretive patterns from photo to photo. This adjustment was especially important, since interpretation is a somewhat subjective procedure and, at various times, four different interpreters were working on the project. This process was repeated for successive stereo pairs and flight lines until land cover interpretation had been completed for both study areas. During the process of interpretation, each interpreter frequently compared his work with the other interpreters on the project to assure uniformity. The relative consistency between interpreters was confirmed by the minimal amount of adjustment that was required where the work of two interpreters merged.

The Kantishna Hills area interpretation required use of three flight lines of aerial photos. Two consisted of CIR photos taken August 1981 at a scale of about 1:60,000; the third flight consisted of BW photos taken July 1951 at approximately 1:52,000. The scale variation between the flight lines required an adjustment in the size of the minimum mapping unit (which was the smallest acreage that, by common agreement, could be considered a distinct vegetation type). It also necessitated some extra work in matching sidelap interpretation. The Dunkle Mine area was covered entirely by one flight line of CIR photos (July 1980, 1:60,000).

Transferring Vegetation and Land Cover Data. The next step involved transferring to a suitable base map the land cover information drawn on the aerial photos. In this case, the interpreted data were drawn onto a series of U.S. Geological Survey 1:63,360 quadrangle map sheets, using a Bausch and Lomb stereo zoom transfer scope. Preliminary transfer was made to paper copies and final transfer went on a stable base mylar format of the 1:63,360 quad maps.

Determining the Area of Vegetation and Land Cover Types. The total acreages of all vegetation and land cover categories found in each study area were calculated using a Talos digitizing tablet coupled to a Tektronik 4054 computer terminal. The calculation results are shown in Table 1.

Results and Discussion

In the Kantishna Hill study area, the commonest cover type is low shrub scrub (Table 1). Upland forest and tall shrub scrub are prevalent too. Floodplain forest is present in smaller amounts, while remaining cover types are much less common. In the Dunkle Mine area, tall shrub scrub is most prevalent, followed by low shrub scrub; forest types are less common than in the Kantishna Hills. In both areas, altered land cover is the least common class of all surface cover types.

The vegetation and land cover classes developed for these areas are generalized, compared to other vegetation classifications used in Alaska. However, the resulting maps provide greater detail than any

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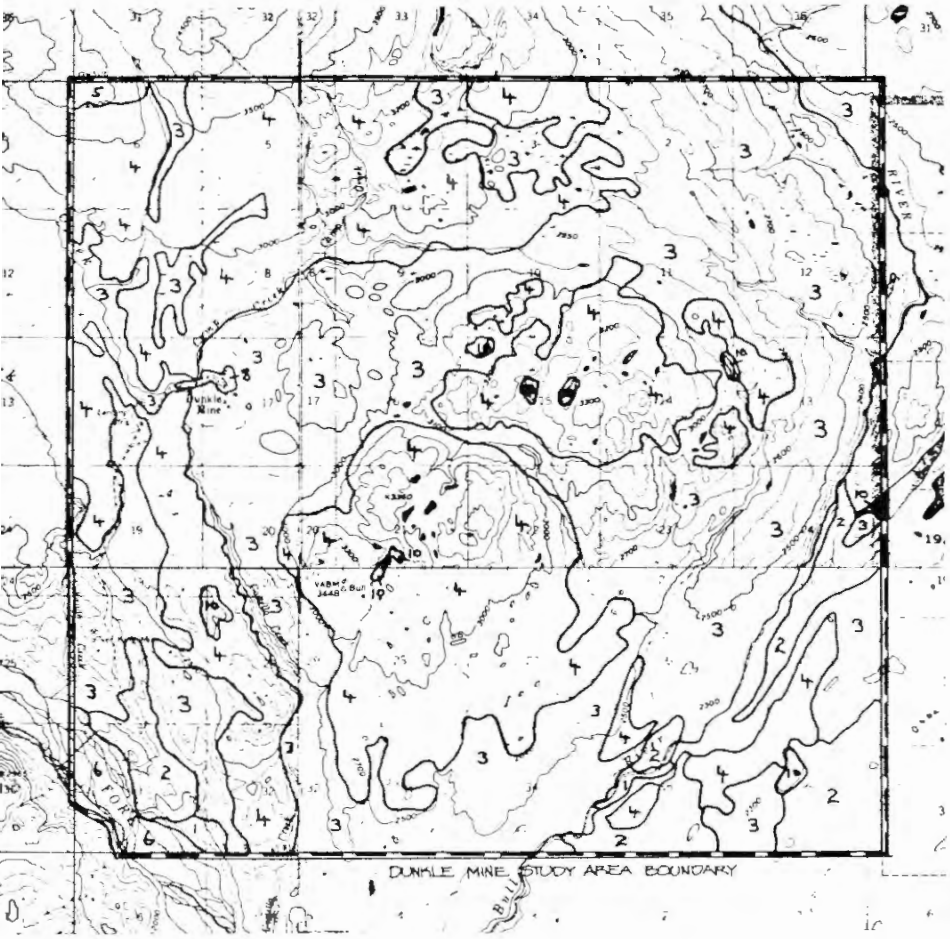

1 FLOODPLAIN FOREST
2 UPLAND FOREST
3 TALL SHRUB SCRUB
4 LOW SHRUB SCRUB
5 ALPINE TUNDRA
6 FLOODPLAIN BARREN
8 ALTERED
10 WATER

FIGURE 2

Land Cover Types in Dunkle Mine Region

Denali National Park and Preserve
United States Department of the Interior / National Park Service

Mining Access Road *developed across alpine tundra cover type is shown in this NPS aerial photograph.*

(Continued)

other known maps of the study areas, and met the need for estimating quantitatively how much of each land cover type would be affected by each land use alternative considered in the EIS.

Although this approach was generalized, because of the abbreviated project deadlines and the inability of the study team to make onsite verifications, it did provide sufficient discriminative ability to show, for example, that placer mining in the Kantishna area would occur disproportionately in the floodplain forest cover type (3% of the Kantishna study area, 12% of which would be affected) and in the tall shrub scrub covering 21 percent of the Kantishna study area, 6 percent of which would be affected.

Summary

The vegetation maps produced from this study provide sufficient detail to make the general calculations and comparisons of cover types needed for quantitative evaluations of the impacts that could be expected from various mining program alternatives. However, because of the generalized nature of the cover types and the lack of ground truthing, the maps are not suitable for use in detailed wildlife habitat surveys, plant ecology studies, or other more specialized uses.

Hunt is a Resource Protection Specialist with the Environmental Assessment Branch of the NPS Washington Office (WASO), Energy, Mining and Minerals Division; Titlow is an Ecologist, Root a Geologist, and Waggoner a Botanist with the NPS WASO Geographic Information Systems Field Unit (Denver), and Dennis is Chief of the Terrestrial and Aquatic Resources Branch, Biological Resources Division, WASO.

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Extra copies of most issues of *Park Science* are available from the editor at the address shown on the masthead.

Dogwood Anthracnose Fungus Threatens Catoctin Mt. Park

By Manfred Mielke and Keith Langdon

Catoctin Mountain Park is a 5,770 acre unit located in the Blue Ridge mountains of north central Maryland. The park contains forests, trout streams and mountain vistas which attract approximately ¾ million visitors annually.

A major management objective of Catoctin Mountain Park is to protect or rehabilitate the native species, natural features and processes of the Park and to maintain the natural abundance, diversity and ecological integrity of wildlife and plant populations.

Flowering dogwood *(Cornus florida)* is a small, deciduous tree that occurs over most of the eastern United States. It is abundant on the rich, well-drained slopes of the Park where it may form an understory canopy. At many locations, it is the only understory species present. Prolific flower and fruit production occurs where significant amounts of sunlight permit. Dogwood flower in April and the red nutlets ripen in October; the seeds usually germinate the following spring. Many species of birds and mammals feed on the fruits and aid in their dispersal. Large trees are 8 to 10 inches in diameter at breast height – about 60 to 90 years old.

The spring blossoms and red to scarlet autumn foliage attract visitors from the Washington, DC/Baltimore corridor and the Park has been host to the First Family at Camp David. The dogwoods, which contribute significantly to the beauty and privacy of this unique site, are being threatened by dogwood anthracnose.

Dogwood anthracnose was first reported in the New York area in the mid-1970s, and was initially confused among several fungi taxa. Further study revealed the fungus associated with dogwood dieback and mortality to be *Discula* sp., probably in the *D. umbrinella* complex.

Symptoms are first noticed as a small purple leaf spot, later forming larger tan areas with purple rims. The fungus may infect additional leaf surface area causing the leaf to curl and eventually die. The fungus also infects twigs, killing them from the tips back, turning them tan and dry. These symptoms generally start in the lower crown and progress up the stem, resulting in the initial common description as a lower branch dieback. Eventually, all branches become infected and die. Epicormic branches (trunk sprouts) frequently occur on diseased stems which are then attacked back to the main stem, causing stem infections. Numerous stem infections often coalesce to kill the main branch.

The fruiting body (acervulus) of *Discula* sp. can overwinter on fallen leaves, on leaves that remain attached through the winter, and on twigs. As more

***Dogwood twig** on a dying tree shows dark lesions caused by anthracnose infection. The white waterspots are fungicide.*

Table 1. Dogwood stems per acre by dieback class

Size Class	Total X̄ Stems per Acre (S/A)	Percent of Total (%)	Standard Error (SE)	Dieback Class 0 S/A:%	1 S/A:%	2 S/A:%	3 S/A:%	4 S/A:%	5 S/A:%
<1"	132	32	33	52:39	37:28	13:10	9:7	9:7	12:9
1–<2"	85	21	18	30:35	23:27	22:25	7:8	4:4	0:0
2–<3"	104	25	13	37:35	10:10	19:18	30:29	8:8	0:0
3–<4"	66	16	9	13:20	9:14	11:17	15:23	15:23	2:3
≥4"	23	6	7	2:9	4:17	4:17	7:30	5:22	1:4
Total	410	100	51	134:33	83:20	69:17	68:17	41:10	15:3

***Anthracnose lesion** on a diseased dogwood leaf is pointed out by pen. The white waterspots are fungicide.*

individuals become infected, the inoculum potential increases to the point where virtually not a single stem can escape attack. Declining dogwoods have been noticed from southeastern New York, southern Connecticut, northern New Jersey and eastern Pennsylvania since 1977 (Daughtrey 1983). When first detected at Catoctin Mountain Park in 1983, it was the furthest south that dogwood anthracnose had been reported, although northern West Virginia and Virginia now have confirmed infections.

Discula sp. has been isolated from leaf spots and twig and branch cankers. Leaf spots and twig cankers have been produced by inoculating isolates onto healthy trees. The pathogen was then reisolated from infected tissue, confirming *Discula* sp. as the causative organism (Hibben, Daughtrey and Hudler 1984). The epidemiology of this disease is not fully understood; however, cool moist spring weather promotes abundant conidial production which, in turn, intensifies the disease and allows it to spread. It is thought that environmental conditions causing winter burn and summer drought trigger dogwood anthracnose development (Daughtry, 1984 and Pirone, 1980). Dogwoods are very shallow-rooted and thus susceptible to drought. No previous record of a foliar disease has been reported to kill flowering dogwood. Trees killed above ground by anthracnose do not resprout.

Methods

A ground survey was conducted in late June and early July 1984. Seventeen survey plots were placed randomly throughout the Park where dogwood populations occur. Each plot consisted of a strip cruise 330 feet long by 8.25 feet wide (5 × .125 chains). Data were collected on all dogwood stems greater than 4.5 feet tall within the strip. Each stem was placed into one of 5 size classes (<1", 1-<2", 2-<3", 3-<4", and ≥4") based on its diameter at 4.5 feet. Each stem was rated for severity of dieback according to the following rating system: Dieback class 0 = Dead; Dieback class 1 = >75 percent of foliage affected; Dieback class 2 = 51-75 percent of foliage affected; Dieback class 3 = 26-50 percent of foliage affected; Dieback class 4 = 1-25 percent of foliage affected; and Dieback class 5 = Healthy.

Results

Dogwood was present throughout the survey area. The mean number of stems per acre greater than 4.5 feet tall was 410. Of these, 32 percent were less than 1 inch dbh, 21 percent were 1"-2", 25 percent were 2"-3", 16 percent were 3"-4", and 6 percent were greater than 4" (Table 1).

Nearly 33 percent of all stems measured were dead (decline class 0). Only 3 percent of stems were completely free of symptoms (decline class 5). Sixty-seven percent of all stems less than 1" dbh were dead or nearly so (decline classes 0 and 1). Forty-three percent of all stems ≥4" were below decline class 3, or had more than 50 percent of their foliage affected. Plots which had a larger number of stems per acre exhibited the most mortality and severity of infection.

Discussion

The disease has been active at Catoctin Mountain Park for several years. In a separate plot of 57 individual trees, rated for 3 years, the decline class ratings for all live trees dropped two levels per year over this period. If this is indicative of disease progress, nearly all dogwoods in the Park will be dead within 3 years.

While the greatest number of healthy individuals were in the <1" size class, those were primarily in areas with fewer stems per acre. In general, the larger stems in any one area were consistently in better condition than the smaller stems. This possibly relates to the position of larger trees in the middle stratum of the forest, an area more likely to be aerated, thus drying foliage and reducing susceptibility of attack. Individuals nearer the forest floor would be more subject to the moist spring conditions that appear to be more favorable to anthracnose.

As might be expected of a newly described pest species, several critical points need further study. Little research has been done on the epidemiology of the disease and more information is needed before definitive conclusions concerning control can be reached.

The origin of this fungus is still unknown; it may be a non-native species spreading from a port of entry for the first time. If so, the impacts on the flowering dogwood can be both widespread and long-lasting. In a parallel development, a similar disease affecting the Pacific Dogwood *(Cornus nuttallii)* has been reported from the Puget Sound Region (Davidson and Byther, 1984). It is also quite possible that the fungus is a native organism that has gone unnoticed, reaching epidemic proportions only after a complex set of climatic events has occurred. Although flowering dogwood leaves are very high in calcium (Hepting, 1971), the affect of acid precipitation and other pollutants, if any, is unknown.

Regardless of the cause, the loss of most dogwoods in Catoctin Mountain Park will mean significant changes in forest microclimatology, wildlife density and recreational enjoyment for several decades to come.

Management Alternatives for Dogwood Anthracnose

1) *No action:* This will likely result in the short-term loss of nearly all flowering dogwood in the park. Should the disease go into remission soon, chances are the larger, healthier individuals will survive and provide enough seed for the long-term restoration of flowering dogwood.

2) *Sanitation:* Badly diseased individuals probably cannot be saved, and due to the sheer number of trees involved this alternative is limited to developed zones. All dead and severely infected dogwood should be cut, removed and burned. On less infected individuals, any dead and heavily infected limbs should be pruned (during dry weather), removed from the area and burned. All epicormic branches should be pruned since they are very succulent and suceptible to infection. Where practical, foliage on the ground should be gathered and burned.

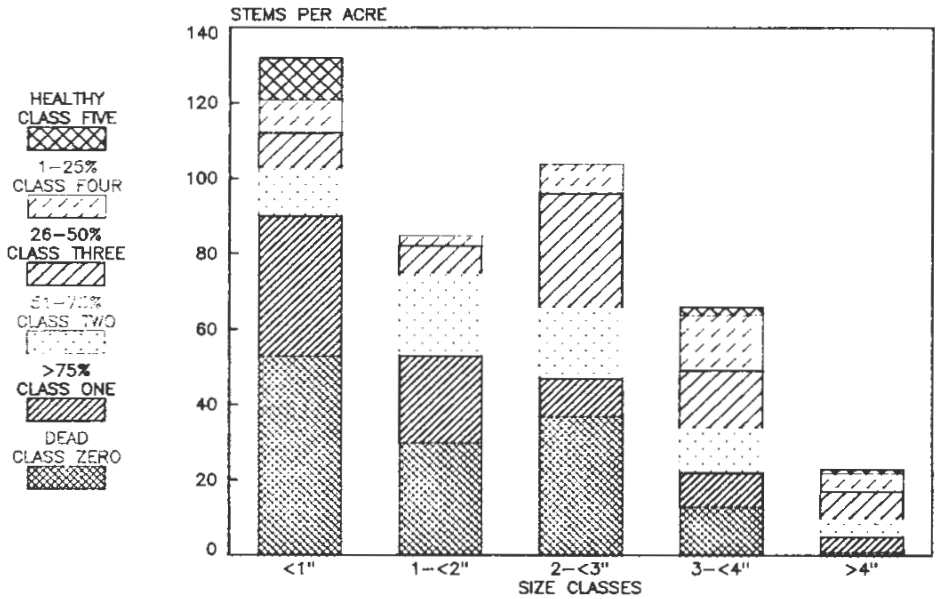
3) *Application of fungicide:* The most susceptible period to infection by *Discula* sp. is in the spring during and after budbreak. During dry periods, try to achieve complete coverage of foliage with any of several fungicides registered for anthracnose fungi. This must be repeated at regular 7-10 day intervals (or more often if it is rainy) and should be continued until leaves have fully expanded. The best control will be achieved

Continued on next page

***These never got started** – dogwood saplings killed by anthracnose at Catoctin Mountain Park in Maryland.*

***This one is finished** – the last surviving sprout makes its appearance on a dying dogwood in the natural zone of Catoctin Mountain Park.*

PERCENT OF FOLIAGE INFECTED BY DOGWOOD ANTHRACNOSE IN EACH OF FIVE TREE SIZE CLASSES



if spring weather is warm and dry.

4) *Integrated Pest Management:* Probably the best control is the combination of sanitation together with fungicide application in conjunction with continued monitoring of disease conditions. In addition, fertilizer applied in the fall after dogwood has hardened off together with water during dry periods in the summer will better enable dogwood to resist killing infections. This type of intense effort can only be undertaken for a relatively small number of trees. A strategy for parks with a severe problem would be to protect accessible dogwoods scattered throughout the unit, thereby hastening natural redisbursal.

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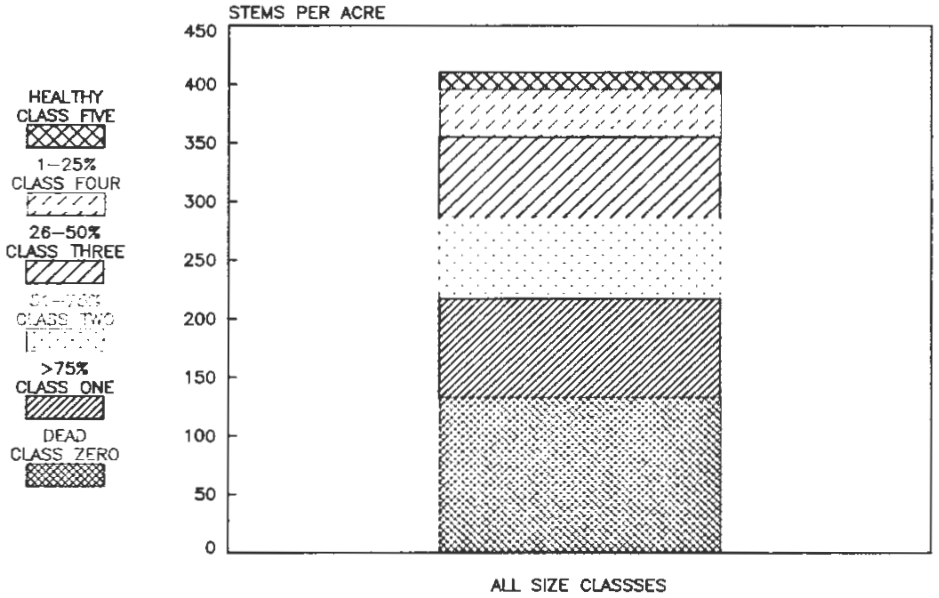
PERCENT OF FOLIAGE INFECTED BY DOGWOOD ANTHRACNOSE WITHIN ALL TREE SIZE CLASSES



Natural Resources Goes to the Movies

Two videotapes on important natural resource topics have recently been developed for use as training materials for field personnel.

Integrated Pest Management in the National Parks is the subject of a 15 minute training videotape prepared by the Biological Resources Division and the Albright Training Center. The video discusses key IPM principles and techniques, including setting threshold levels, monitoring, and using natural parasites, predators, or pathogens to control the pest population. The video then highlights various NPS units which have successfully implemented IPM programs.

The IPM video is part of a natural resources training program being developed by Doug Morris and Sue Toole at Albright Training Center. This program will provide orientation to NPS employees on resource management topics including ecological principles, laws and policy, research, monitoring, and communications. The program is designed for use at the park and is presented through a variety of media including film, video, and workbook. The program will be available for park use in Spring or Summer 1986.

The NPS Geographic Information Systems Field Unit and the WASO Training Division recently collaborated on a 25-minute training videotape on the Service's Geographic Information Systems (GIS) program. The video provides a basic introduction to the GIS technology; reviews how a GIS can typically be used to support park management, planning, and operations activities; and outlines the services the GIS Field Unit can provide to parks in developing and implementing their GIS. The video also focuses on four "real-life" examples of parks where a GIS already is in use.

For more information about the Introduction to Resources Management program, contact Doug Morris, Albright Training Center, 602-638-2691.

For more information about the IPM videotape, contact your Regional IPM Coordinator or Gary Johnston, Servicewide IPM Coordinator at FTS 343-8130.

For more information on the GIS videotape, contact Phil Wondra, Geographic Information Systems Field Unit, FTS 776-7939.

'Green Sickness' Prevention And Control In Oregon Caves

By Tom Aley, Director
Ozark Underground Laboratory,
Protem, Missouri 65733

If you were to go to Lascaux Cave in France, a world-famous site of prehistoric cave paintings, you would find the cave closed to visitation. It is closed because of the "Maladie Verte" (the green sickness), which affects, to varying degrees, almost all electrically lighted caves visited by the public. The green sickness is the exotic growth of algae and moss on cave surfaces. In Lascaux Cave, the growth (which largely consisted of a green alga) was covering and destroying the prehistoric cave paintings, so to protect the resources, Lascaux Cave is no longer lighted and is closed to the public.

Oregon Caves National Monument is located in the Klamath Mountains of southwestern Oregon. The site became a National Monument in 1909, and the caves, which have been electrically lighted and toured for many years, have been dramatically affected by the green sickness. Post cards available at the Monument commonly show greenish speleothems (cave formations): their natural colors are whites, greys, and earth tones.

Plant growth in caves is not simply a visual impact. Algae and moss can seriously damage speleothems. If the growth is allowed to persist, speleothem surfaces are etched and dissolved by plant growth, and in places, the surfaces of speleothems are turned to a jello-like substrate by algal attack.

Research on natural resource problems in National Parks often seems to be independent of construction and other activities which may be related to the problems. This was not the case at Oregon Caves. In late 1984 we began studies on exotic plant growth and methods of preventing and controling it in Oregon Caves. Our investigations were prompted by three factors. First, we had conducted a major study in 1983-84 of exotic plant growth in Carlsbad Caverns, New Mexico where we were able to determine quantitatively the light intensity thresholds below which plant growth was greatly reduced and commonly prevented. These findings suggested that exotic plant growth studies should be a part of planning for new cave lighting systems. The second factor was that new electrical systems were being planned for Oregon Caves Monument and its caves and the contract to do this work had been let. The third factor was good communications, both within the Pacific Northwest Region and between that region and the Southwest Region, which led to recognition of the potential applicability of the Carlsbad Caverns study to Oregon Caves.

The flora of the naturally dark portions of Oregon Caves is large and diverse. To date, we have found two species of ferns, 11 species of moss, and, (including species reported by St. Clair et al, 1981), 51 different algae. It seems likely that, with more collecting, we would find that the Oregon Caves flora consists of more than 100 different species.

In Oregon Caves, about 15 percent of the areas covered by visible plant growth supports mature moss; another 10 percent supports moss protonema. About 40 percent of the visible plant growth areas supports blue-green algae, and about 35 percent supports green algae. Diatoms, which are very small and generally do not cover large areas, are present in about half the samples of algae and moss protonema.

Substrates exert major influence on the extent of plant growth in Oregon Caves; the following generalizations apply:

A. Plant growth is greater on wet or very moist surfaces than on damp or nearly dry surfaces. Most surfaces in Oregon Caves are at least damp for part of the year.

B. Plant growth is greater on weathered speleothem surfaces and on surfaces coated with moonmilk than on firm speleothem surfaces.

C. Plant growth is greater on muddy speleothems and muddy marble than on clean and solid speleothems and marble.

D. Plant growth is greater on lint "globs" and clay worms than on adjacent lint and clay worm-free surfaces. This difference is most noticeable on firm spelethem or marble surfaces.

E. Plant growth is greater on relatively flat surfaces than on steeply inclined surfaces, and greater on steeply inclined surfaces than on cave ceilings.

F. Plant growth is greater on broken margins of trail materials than on firm trail surfaces.

Clay worms are curving, tubular clay deposits which are scattered about on many surfaces in Oregon Caves. They are typically less than an inch long, and, based on limited samples, they consist of about 70 to 75 percent muscovite, with the balance being quartz. The worms typically have lint and algae associated with them.

Clay worms appear to be an unnatural feature of the caves, related to human actions, and tied to three unnatural conditions in the caves:

A. Airflow caused by the construction of new entrances, tunnels, and passage excavations which moves tremendous volumes of air, dust, pollen, and other air-contaminants from the surface into the cave.

B. Visitation of the cave, which introduces lint, hair, an other similar materials into the cave, providing substrates and nutrients favorable for plant growth.

C. Electric lights needed for cave touring, that cause plant growth on the clay worms. Plant growth may be associated with the development and/or enlargement of clay worms.

Many of our investigations in Oregon Caves focused on light intensity. We found at least some visible plant growth associated with all fixed lights in Oregon Caves. There does not appear to be a particular light intensity that maximizes plant growth in Oregon Caves, since abundant growth occurs over as wide a range of light intensities as 28 to 164 foot-candles. At least some "spotty" plant growth occurs at favorable sites where light intensities are as low as 2.5 foot-candles. (A foot-candle is the light intensity of one standard candle at one foot's distance.)

Mature mosses are particularly destructive to speleothems. Based upon our data, it appears that mature mosses will be rare in areas receiving less than about 6 foot-candles of light. Our data also show that, if light intensities are controlled to minimize mature moss growth, then fern growth also will be controlled.

Approximately 85 percent of plant growth now found in Oregon Caves could be prevented if light intensities reaching moist surfaces did not exceed 4 foot-candles. For ideal plant growth prevention on sensitive cave features, light intensities at these features should not exceed 2.5 foot-candles.

It appears to be neither possible nor feasible to prevent all exotic plant growth in Oregon Caves. Some plant growth will become established and must be controlled. We found that a 5.25 percent sodium hypochlorite solution (bleach) is the best plant control agent in Oregon Caves. The use of bleach is far superior to the use of germicidal lights, herbicides, or other potential control agents. Bleach solutions of less than 5.25 percent sodium hypochlorite did not produce acceptable kills of exotic plants in Oregon Caves; solutions with greater concentrations do not appear necessary. We found that sodium hypochlorite solutions of the recommended concentration seldom if ever alter the color of speleothems. However, careful examination of areas to be treated and areas that have been treated is prudent and is recommended, since some generally rare cave features might suffer color changes.

Two principal ways in which plant growth in Oregon Caves can be minimized and prevented are:

A. By careful control of the intensity, duration, and location of the cave lighting.

B. By frequent and routine control of any plant growth that does become established.

We have worked closely with Dick Fay of Engineering and Design Associates of Tigard, Oregon (the lighting contractor) to establish criteria for the intensity, duration, and location of cave lighting. This work included several days spent together in Oregon Caves, data from our studies, and visits to three other caves with widely varying lighting systems. (Wind Cave and Jewel Cave [both NPS units in South Dakota] and Blanchard Springs Caverns in Arkansas [a U.S. Forest Service show cave].)

Lighting systems for show caves are routinely designed to provide for good interpretation and adequate visitor safety. The new lighting system for Oregon Caves will extend beyond these aims in that it also will be designed to protect cave resources from exotic plant growth and its associated damage. Such an approach could set a precedent for new lighting systems in other NPS caves. To paraphrase the "A-Team," I love it when a plan comes together, and when the research is done at the right time and is integrated into the plan.

New Technology Allows Counting Of Cave Visitors

By Steve W. Chaney

Somewhere in the depths of Arkansas' longest cave system an eye awaits, silent and motionless, peering down the cold stone and mud corridor, waiting for the approach of an unsuspecting cave visitor. The creature to which this eye belongs is not really an unfriendly chap. The eye is made of black rubber silicon and printed circuitry and is attached by a small cord to the creature's body. The creature is a creation called "Spelogger."

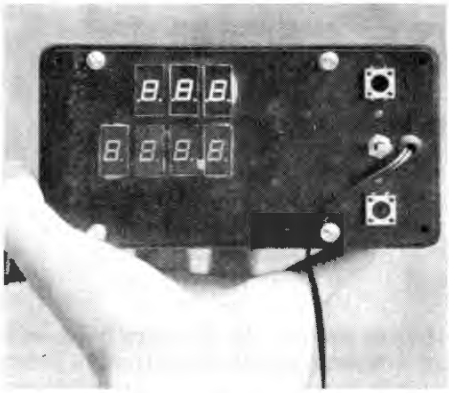
The Spelogger is a recent innovation, developed by a volunteer cave researcher at Buffalo National River. Its sole purpose is to lie in wait, in remote and often inhospitable cave passages, for the approach of a light source – usually from a caver's helmet. This light triggers the photoelectric "eye" sending an impulse to the Spelogger which records the time and date in its electronic memory. Once triggered, the photocell does not reset itself until several minutes after the light source(s) has passed, which, in effect, creates a record of the time and date that any individual or group of cavers pass the device.

This may sound like a simple concept; however, several unsuccessful and costly attempts have been made to develop a method to obtain just such data. While the market for such a device may be limited by the number of organizations responsible for cave management, the applications within this circle are almost limitless.

Several million dollars have been spent in recent years by agencies such as the National Park Service, U.S. Fish and Wildlife Service and the Bureau of Land Management to protect habitat utilized by endangered bat species. This protection often consists of fencing or gating caves, or sometimes simply purchasing the property and implementing a voluntary permit system, prohibiting cave visitation during periods when bats use the cave. Bat caves are notoriously remote and difficult to access, therefore, little more than a guess can be made as to the effectiveness of these protective measures. This huge investment with no means to measure the action's effect is of great concern to managers of such caves.

Using the Spelogger, absolute data may be obtained showing if and when any violations of cave closures have occurred. Managers may then react in a reasonable and more effective, cost and manpower efficient manner to correct any problem. With the time and date information, investigative action may be taken which at best is likely to identify violators or at least will allow determination of periods in which enforcement activities should be concentrated. Such data might also provide information necessary to determine whether or not more drastic and expensive measures such as cave fences or gates are necessary.

Use of the Spelogger to solve problems related to endangered bat caves may be only scratching the surface of its overall potential. Many caves or internal portions of caves are gated simply due to a lack of information concerning use levels. Additionally, many use limits placed on caves are somewhat arbitrary due to the impossibility of obtaining accurate data as to numbers of cave users in specific areas or passages. The possibilities for further uses include cave search and rescue operations – the tracking of a group or an individual through use of the time and date information.



***The Spelogger**, compact, light and durable, was developed by D.R. Russell, Volunteer Cave Researcher at Buffalo National River. It promises to be a valuable tool in cave resource management.*

You may say, "all this sounds well and good but nobody is willing to lug a monitoring device miles into a cave and then be faced with its constant maintenance and service." This is one of the real values of the Spelogger. It was developed by a caver, familiar with the cave environment and the logistical problems of cave travel. The Spelogger is about the size of a small box of Velveeta cheese, weighs 15.5 ounces including its four AA alkaline batteries, which will power the device for over 200 days and enable it to record up to 2,048 events (triggering of the photocell). The photodetector has a minimum sensitivity of .0001 foot-candle which amounts to the light from a flashlight on the far side of a large cave room and the clock is a crystal-controlled oscillator, accurate to ± 0.005% (14 minutes in 200 days).

But perhaps the most attractive thing about the Spelogger is that it was developed entirely through volunteer efforts. The researcher, Rod Russell, who works as an engineer at an Arkansas Power and Light nuclear power station, was attracted to Buffalo National River by his boyhood love for Fitton Cave and by the availability of data from a National Park Service-administered permit system, which could be used to check the device's accuracy during field testing. Another attraction was the Buffalo National River's volunteer research program, which grants volunteer researchers special privileges such as use of a backcountry cabin for an overnight facility, and use of some access roads otherwise used for administrative purposes only.

We are pleased to have participated in the development of this technology. The Spelogger, an exciting new development in the realm of cave use monitoring, promises to be a building block for future cave management programs.

Chaney is Resource Management Specialist at Buffalo National River.

letters

After reading the article on the design of nature reserves by Quinn, van Riper, Karban, Robinson and Harrison in the last issue of *Park Science*, I felt it important to comment on several aspects of their study. The question of reserve size is very important, particularly in tropical and developing countries. We therefore have to be careful in our design of studies and in our evaluation of their results.

Quinn et al may not be realistically approaching the problem with their small study plots in a sheep pasture. A 2 m^2 plot is much smaller than any normal reserve design and is really analyzing diversity patterns at a very local scale. The authors seem to be rediscovering a well-known phenomenon in plant ecology – that a series of small plots scattered across a site will contain more species than a single large plot of the same total area. A second problem with this aspect of the study is their use of grassland. Many grassland species are good invaders and are disturbance tolerant, as are the marine intertidal organisms of their second experiment. It remains to be seen if they are replicating the processes of isolation that influence larger preserve areas or if the types of organisms are representative of extinction prone species.

Quinn et al are closer to reality in their investigation of islands and of actual national parks, but there are also some problems here. They do not seem to consider the difference between comparing a series of small parks that are in the same region with a large park from the same area and comparisons that are between regions that may have widely differing patterns of diversity and habitats. The example of combining Redwoods, North Cascades and Big Bend and then comparing it to Yellowstone is totally unfair because the former three parks are from such different zoogeographic areas and one automatically will increase diversity by summing checklists of parks from different regions. A more realistic question is: if Yellowstone were 25 percent of its present size or did not occupy the entire basin, how many species of large mammals would it support?

Ron Miller, Peter White and I recently sent a manuscript to *Biological Conservation* (its fate is still unknown) that suggests for rare plants in the Southern Appalachians a series of small preserves is less expensive per species preserved, but is probably not as biologically desirable as a large core reserve surrounded by a selected group of smaller reserves. The models were constructed not just with species lists but also with distribution data. Although I think the work of Quinn et al will make a valuable contribution to our understanding of biogeographic processes, they need to be cautious about drawing conclusions about patterns on one scale from data collected at another.

Susan P. Bratton, Coordinator
NPS Cooperative Research Unit
U of Ga. Institute of Ecology
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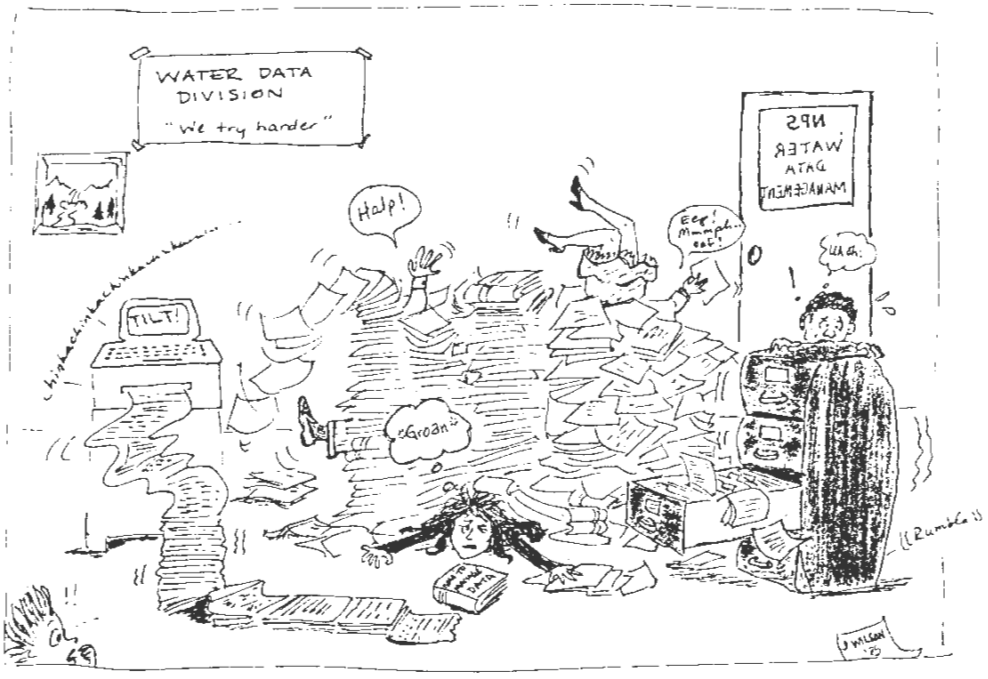
Editor's Note: A fuller treatment of the Bratton/Miller/White work in this area will be carried in the Spring 1986 issue of Park Science.



How to Handle Water Data Without Getting Drowned

By Richard Inglis

As natural resource managers in the National Park Service, we've all encountered water quality reports or technical information that for some reason is not put to use. Perhaps we don't know enough about the subject to use it properly, or perhaps it doesn't apply to current projects. Yet the report contains valuable information that could be essential to resource management. Too often, that piece of information becomes lost in a file or on a bookshelf, rarely to be used and ultimately to be discovered too late and discarded. The purpose of this article is to help prevent the "lost value" of good information.

Factors that can contribute to this regrettable "lost value," begin with the reader, who may not have sufficient technical knowledge for understanding content meaning. The information may become buried in piles of papers or misplaced in the files, or be stored in a computer where it is inaccessible or incorrectly filed. A user may simply be intimidated, confused, or frustrated by computers. Most of us have experienced these and other situations that intertere with access to information.

Acquiring Information

Try to keep data acquisition to a minimum and manage it diligently. Your objective is to organize information into a hierarchical structure, with you on top of the pyramid of knowledge where the encompassing ideas are found.

Each successive level downward should add information until the bottom level is reached, with its broad base of super-detail and quantity of datum. The intervening levels are blends of theory and facts such as report summaries and research syntheses. Raw data are used when there is a distinct need. Get data from the lower levels of the pyramid only when the project calls for it. If there is an honest gap, then develop a study or resource monitoring program to acquire the needed data. Keeping the following four points in mind also will help with information management:

1. *Know what you need.* As a natural resource manager, keep a broad knowledge of the hydrologic cycle in mind. Know basic ecological and watershed principles and relationships. Try to generally understand the regulatory framework in your state and how significant federal laws apply. Don't memorize all the constituents of water quality. Don't try to understand the details of groundwater movement. Don't worry about statute numbers affecting discharges into rivers. There are specialists who have this information and who keep the appropriate reference books.

2. *Know where to get it.* In your own park and in your regional office, learn how each outfit is organized so that you know who is responsible for which categories of information. In larger park units, good sources of water supply information are in engineering, maintenance, and public health & sanitation divisions. Learn what the various divisions of the NPS do and how they keep records. The Water Resources Division in Ft. Collins is in an excellent position to assist park areas in remote locations in satisfying their information needs. Besides the NPS structures, university libraries and federal depositories have good collections of technical reports. Most major libraries can tap into water resource, environmental or geological abstracts through computer searches. Other federal agencies are often the primary source of water quality and quantity data, although it may take several attempts to locate the right person in the right place who can really help you.

The EPA and the Water Resources Division of the USGS are good starting places and are often listed in the telephone directories of large cities. The EPA regional offices all have divisions that collect, store, and assess water quality data, and the USGS Water Resources Division has offices in every state (many states have several offices). However, when pursuing information from such agencies, it is important to be persistent as it may take several calls to find the department that handles water data. Be prepared to communicate exactly the information you seek so that the agency can more effectively direct you to the person(s) who can help you.

3. *Know how to get it.* Be persistent. Learning where to get the right information may be time consuming at first but will save time in the long run. If you seek hard data, find out in what format it comes and whether interpretation and analysis is available. Inquire about the various means of transmittal. With data retrievals done by computers, you will need to know what kind of computer hook-up is needed. Remember to secure the provider's name, complete address, and phone number so you can contact him or her with any questions and follow up with a thank you.

4. *Know who can help you.* One potential source is an experienced person in your own park who may have done a similar project. In addition, the NPS Water Resources Division has specialists that are available to help with water problems. Media vehicles such as *Park Science* and the *George Wright Forum* highlight the work of other NPS scientists, some of whom may be conducting projects of interest to you. Some state governments have an environmental clearinghouse that can guide you through hurdles that may appear at the local level. In time you will have a network of individuals able to help you obtain information quickly and with minimum effort. Stay friendly with your network; you may need help again.

Categorizing Information

Incorporate into your work-life small habits that organize information. Use of index cards in a file box is an old standard that works, but it needs regular attention. Folders can be used sparingly in your desk for bibliographies, research systems, etc. Use the existing record-keeping system to your advantage to organize the bulk of the paperwork that has more to do with governmental procedure than scientific value. Although some things can be filed, most official NPS correspondence is sent to the National Archives through the NPS records management. Spend a minute thinking on each piece of information you deal with: does it get you higher on the knowledge pyramid or down in a mire of details? The following are some tips for making this distinction:

– Much information can be discarded if you see no critical value in it. For example, circulars, catalogs, flyers, announcements, product promotions, news releases, reviews, etc. can be routed to others who need to see them or may be interested in their content. If no one else needs to keep such material, you can feel safe in discarding it.

– Some information should be filed in the record system for a certain period of time (such as one year). For example, memos, correspondence, budget material, project proposals, and so forth should be kept according to the record management handbook. Send them to the central files of your park headquarters or regional office.

– Some information should remain in a permanent or semi-permanent filing system. "As built" drawings, specifications from contracts, original or field data, ground truth evidence, water right documents, permits, land deeds, and other important or legal docu-

Continued on next page

Water Data Continued

ments should be recorded and filed as appropriate in a library, dockets, or permanent files at park headquarters, and/or Regional office. The Water Resources Division has a functional system for storing water resource data that is organized by individual park unit for NPS units across the nation.

It is easy to be overwhelmed by the abundance of data and information in our world today. What is critical is not how much you know but how well you can *use* what you know. Beware of Data Heap, Computer Dump, or Information Overload! Two of the most important things to know are 1) where to get needed information and 2) how to get it efficiently. Thus, in this "Information Age," you will have information only a *file drawer*, a *phone call*, or a *computer key* away – and still be able to use it!

Inglis is Hydrologist with the NPS Water Resources Division, Fort Collins, CO 80521.

Jeffrey L. Marion

Research Biologist Joins Mid-Atlantic Region Staff

The staff size of the Mid-Atlantic Region's science program doubled recently when Jeffrey L. Marion accepted a position as research biologist. Jeff is stationed at Delaware Water Gap NRA, where his responsibilities will center around major research in cooperation with the Forest Service's NC Forest Experiment Station to study river recreation use and carrying capacity at Delaware Water Gap, New River Gorge National River, and the Upper Delaware Scenic and Recreational River. His research will involve assessment and monitoring of resource impacts from river recreation use and, as time permits, he will dabble in the investigation of impacts of visitor use on the Region's trails, earthworks, and dunes. Jeff has a strong interest in transferring the findings and implications of his efforts to field managers through the development and instruction of resource monitoring techniques and microcomputer applications.

Jeff earned his Ph.D. in recreation resource management at the University of Minnesota in 1984 and was assistant professor at the University of Wisconsin before coming to the NPS. His doctoral research investigated the ecological changes resulting from recreational use of backcountry campsites in the Boundary Water Canoe Area Wilderness of Minnesota. In 1981 Jeff assisted Dave Cole at the USFS Intermountain Forest Experiment Station in wilderness management research studies to determine how recreational impacts relate to amounts of recreational use over time and to variation in ecosystem types. Jeff co-authored with Cole an article on Limits of Acceptable Change that appeared in the Fall 1985 edition of *Park Science*.

regional highlights

Southeast Region

The following Research/Resources Management Reports now are available from the Uplands Field Research Laboratory, Great Smoky Mountains NP, Gatlinburg, TN 37738:

Nicholas, N.S. and P.S. White. 1984. The effect of balsam wooly aphid infestation on fuel levels in spruce-fir forests of Great Smoky Mountains National Park. (R/RM Report SER-74)

Peine, John D., Craig A. Walker, Paul H. Motts and William E. Hammitt. 1985. Evaluating communications with visitors to Great Smoky Mountains National Park. (R/RM Report SER-75)

Peine, John D., Charlotte Pyle and Peter S. White. 1985. Environmental monitoring and baseline data management strategies and the focus of future research in Great Smoky Mountains National Park. (R/RM Report SER-76)

* * *

Southeast Regional science editor Jim Wood, who also is doubling as editor of the Park Service's Servicewide Science Publications Program, has announced the acceptance of a new manuscript for publication in the Service's Natural History Series: "The Forests of Mount Rainier National Park: A Natural History" by William H. Moir. The manuscript is currently undergoing final revision and is scheduled for typesetting and publication by mid-1986.

Pacific Northwest

R. Gerald Wright, research biologist with the NPS/CPSU at the University of Idaho in Moscow, is one of two winners of the Herbert E. Kahler Research Fellowship, awarded by the Eastern National Park and Monument Assn. The fellowships, for $5,000 each, are for research in fields relevant to the broad interests of the National Park Service. Robert M. Utley, chairman of the Eastern National board, announced the decision of the Research Committee, headed by James C. Olson, president-emeritus of the University of Missouri.

The other winner was Dr. Charles H.W. Foster, former dean of the Yale School of Forestry and Environmental Studies. Wright's study is on the evolution of wildlife management philosophies in the national parks, and will culminate in publication of a book.

Two articles by Wright appeared in 1985. He was sole author of "Principles of new-park area planning as applied to the Wrangell-St. Elias Region of Alaska," in Environmental Conservation 12:59-66, and co-author with P. Hayward of "National parks as research areas, with a focus on Glacier National Park, Montana," in the Bulletin of the Ecological Society 66:354-357.

Mid-Atlantic

A 700-acre research natural area has recently been designated in Shaver Hollow at Shenandoah National Park. The area has high biological diversity and is a key watershed and acid deposition monitoring site for the eastern United States. It is also the first NPS research natural area in the eastern deciduous forest region, and one of very few such areas established in recent years.

Midwest Region

Sleeping Bear Dunes National Lakeshore has completed resource management action plans for Manitou Islands deer and the exotic mute swan. The deer plan describes the history of white-tailed deer on the eastern Lake Michigan islands, the action of deer in altering the natural vegetation of North Manitou Island and objectives for managing the existing deer herd. The plan states the NPS, with the cooperation of the Michigan Department of Natural Resources, will annually assess the need to conduct a public recreation deer hunt to achieve deer population levels within the island's carrying capacity. The mute swan management plan describes the increasing mute swan population in the lakeshore and calls for continued study of the swan and its impact upon lakeshore visitors and wildlife. It also outlines procedures for controlling individual problem swans.

* * *

The 22nd Annual Lake Superior Biological Conference was held Sept. 27-28, 1985 at Michigan Tech U., Houghton, Mich. Five of the 24 papers presented involved research in national park units on Lake Superior. Following are NPS papers and authors:

Pre- and post-logging fire regimes within Pictured Rocks National Lakeshore – Walter L. Loope, Resource Management Specialist, Pictured Rocks; *Lichens and air quality in Isle Royale National Park* – Clifford M. Wetmore, contract researcher, University of Minnesota; *Effects of atmospheric acid deposition on watershed/lake ecosystems of Isle Royale and Michigan's upper peninsula* – Robert Stottlemyer, CPSU, Mich Tech U.; *Soil anion mobility in northern hardwood and boreal forested watershed ecosystems in the upper peninsula of Michigan* – Robert Stottlemyer; *Wolves, moose, and vegetation in Isle Royale National Park* – Rolf O. Peterson, contract researcher, Mich. Tech.

Southwest Region

"A massive compilation of data that will be recognized as the definitive work on mountain lions of the Southwest," is the way Southwest Regional Chief Scientist Milford Fletcher describes the three-year study, "Ecology of Mountain Lions at Carlsbad Caverns/Guadalupe Mountains National Parks," available after December 1985 from the NPS Southwest Regional Office, Old Santa Fe Trail, P.O. Box 728, Santa Fe, NM 87501.

Tom Smith was the principal investigator for Harvey and Stanley, Inc., of San Jose, Calif., with whom the NPS contracted for the study. Smith lived on the site, studied and tracked the lion for three years. The report contains management recommendations.

By Jan. 1, 1986, Fletcher said he would have a computerized home range program that covers all known mountain lions, their ranges and overlaps, ready for running on an IBM PC XT. The program will be available to anyone interested.

* * *

Continued

The hitherto unknown life story of the Atlantic Ridley turtle was pieced together during an exciting weeklong conference in October 1985 at Texas Tech in Galveston, sponsored by the National Marine Fisheries Service and others, according to SW Regional Chief Scientist Milford Fletcher. An article describing the conference findings, including turtle egg incubation temperatures and their effect on the sex of the young turtles and the overall chances of species survival will be carried in a forthcoming issue of *Park Science*.

Water Resources Division

"Giardia in the Backcountry," by Sam Kunkle of the Water Resources Division staff, appeared in the October 1985 issue of *Journal of Forestry* (Vol. 83, No. 10, pp. 612-613).

* * *

Dave Beeson of the NPS Water Resources Division staff at Colorado State University, held a poster session about lake history in Rocky Mountain NP as indicated by diatom taxonomy and stratigraphy at the 8th North American Diatom Symposium held recently at the Handcock Biological Station in Kentucky.

* * *

Division work for the Rocky Mountain Region recently includes map making on the change in point of use applications for water rights in Rocky Mountain NP, a flood study for Arches NP, and a review of the Department of Energy's revised methodology for ranking sites suitable for the nation's first high-level nuclear waste repository.

A progress report, submitted by the Flathead River International Study Board to the International Joint Commission on the status of the investigation of transboundary water impacts of the Cabin Creek Coal Mine north of Glacier NP, provides background on the study's approach, organization, and issues and problems that have become evident. The Board's recommendation was to extend the study's deadline from May 15 to Dec. 15, 1986.

* * *

For the National Capital Region, the Water Resources Division began work with the C & O Canal NHP to develop the FY 86 scope of park flood study work. This phase will focus on threats to special features and historic structures.

For the Midwest Region, the Division has forwarded a proposal for a three year study on the St. Croix River, involving ecological characterization: biological assessment of aquatic resources.

* * *

For the Pacific Northwest Region, the Division made its final inspection of the new water facilities at Nez Perce NHP and is following up on a possible water quality question reflected by increasing chlorine demand. A proposal is now available covering Lake Crescent, Olympic NP, sediment work to include pollen, charcoal, and diatom stratigraphy.

* * *

In the Alaska region, the Water Resources Division took part in a planning meeting on preparation of a handbook that will deal with environmental effects of placer mining. The booklet will present an overview of placer mining technologies, identify placer mining state-of-the-art, enumerate environmental impacts and what can be done to mitigate them.

Western Region

David J. Parsons, Research Scientist at Sequoia and Kings Canyon NPs, was recently elected Vice-Chairman of the Vegetation Section of the Ecological Society of America. He will serve in that capacity until August, 1987.

* * *

A technical report, entitled "Techniques of Revegetation and Reclamation of Land Damaged by Off-Road Vehicles in the Lake Mead Recreation Area," by James Russell Marble, is now available from the NPS Cooperative Park Studies Unit, University of Nevada, Las Vegas.

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The Third Biennial Conference on Research in California's National Parks has been scheduled for Dec. 15 and 16, 1986, at the University of California, Davis.

* * *

Resource Management Trainees returned to the University of California at Davis in October for a three-week course, entitled "Advanced Wildlife Management." Course topics included seabird community organization and dynamics, predation and disturbances in natural communities, bear ecology and management, basic statistics in population ecology, environmental contaminants in wildlife populations, maintaining viable populations, endangered species management, and modeling wildlife-habitat relationships. The course was conducted as a cooperative program between the NPS and the University.

* * *

The first report to be published in the new "Biological Report" series by the Research and Development branch of the U.S. Fish and Wildlife Service is now available. Biological Report 85 (7.2), dated May 1985 and entitled "The Ecology of Giant Kelp Forests in California: A Community Profile," includes sections on the biology and ecology of surface canopy kelps; physical, chemical and geological aspects of the kelp forest environment; community structure and energetics; and the natural history of organisms in the community.

* * *

A description of static pile composting, begun at Redwood National Park in 1982, is contained in Technical Report 14, Redwood NP Research and Development, entitled "Temperature dynamics, oxygen consumption, and nitrogen utilization in static pile composting," by Jeff Purkerson, John Sacklin, and L. Lee Purkerson. Composting provides both a solution to waste disposal problems involving chemical toilet and septic tank wastes and a product useful in the park's watershed rehabilitation program. Results of studies to improve the operation's efficiency and evaluate the usefulness of the end product have been published in a series of Operation Manuals and reports, and will be published in condensed form in scientific journals.

Dan Huff Heads Science In Rocky Mountain Region

Dr. Dan E. Huff of Golden, Colo., on Sept. 29, 1985 became Regional Chief Scientist for the NPS Rocky Mountain Region, which embraces 41 parks in six states. Huff, 41, has served as a natural resource specialist and park planner with the Denver Service Center.

As Regional Chief Scientist, Huff is responsible for directing and coordinating scientific activities by park employees, college and university researchers, and contractors on such issues as grizzly bear recovery, air and water quality, wildlife management, and development conflicts. Most recently, Huff has captained teams that have developed management plans for Glacier Bay NP and Preserve, Ozark National Scenic Riverways, New River Gorge National River, and Assateague Island National Seashore. Huff joined the NPS in 1977, after a professional career in academia, research, and chemistry.

NPS/CPSU Established At Tennessee University

Peter S. White, former head of the Uplands Field Research Lab at Great Smoky Mountains NP, is leader of a new NPS Cooperative Park Studies Unit at the University of Tennessee. The CPSU is the outgrowth of the Cooperative Agreement between the park and the university, which was renewed and expanded in March 1985.

White took up his new duties in September, but will continue to supervise plant ecological research in the Smokies. His new address and phone number are: NPS CPSU, Forestry, Fisheries and Wildlife, University of Tennessee, Knoxville, TN 37901-1071. Phone: (615) 974-8181.

Social Scientists To Meet At OSU

The First National Symposium on Social Science in Resource Management, to be held May 12-16 at Oregon State University in Corvallis, will result in a series of theme oriented edited books instead of the usual "proceedings" from the conference, according to Donald R. Field, social scientist with the NPS CPSU at OSU and conference chairman.

Underlying goal of the symposium is to provide a forum for exchange of information among social science professionals on a wide variety of resource issues associated with oceans, coastal zones, forests, parks, and preserves.

The contemplated books will reflect the resource economics area, cultural resources, recreation, communication and interpretation, community and natural resource issues, social behavior and natural resources. Those wishing to have their presentation paper considered for publication in one of the volumes should submit a completed paper to the theme organizer by April 1, 1986. For the various theme organizers and their addresses, contact Don Field, (503) 754-2043.

Visual Air Quality and the National Park Visitor

By David M. Ross and William C. Malm

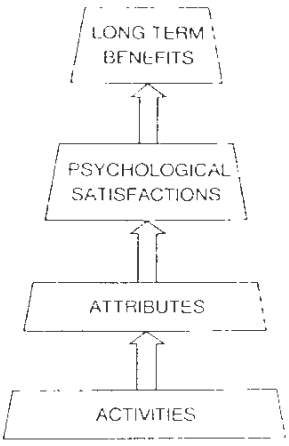
By mentioning the importance of sweeping vistas, enabling legislation for National Parks often alludes to the importance of good visual air quality as a part of each park's uniqueness and natural beauty. The Clean Air Act (CAA) and its amendments in 1977 reinforced the importance of air quality related values (including visibility) and declared it a national goal for so-called "Class I areas" to prevent any future, and to remedy any existing, visibility impairment caused by man-made air pollution. The CAA made Federal Land Managers of Class I areas responsible for protecting such values and ensuring that no major new facility will have an adverse impact. When determining whether a change in existing air quality will have an adverse impact, the NPS traditionally has considered whether the change will: 1) impair the quality of the visitor experience; 2) impair the structure and functioning of the ecosystem; and or 3) diminish the national significance of the area.

These decision criteria are broad and leave unanswered many important questions. For example, how can the quality of the visitor experience be assessed? How important is good visual air quality to park visitors? What effect, if any, does a reduction in visual air quality have on visitor enjoyment and/or satisfaction? Does the importance of good visual air quality vary from park to park, from region to region?

Historically, the bulk of information gathered about park visitors consisted of keeping records on the number of people who came to a park, stopped at the visitor center, stayed at the campgrounds, etc. However, tracking numbers did not reveal why people were coming to the areas and what type of recreational experience they were seeking. Recently, recreation demand theory has evolved to allow for management of recreation as an experience, and some managers are beginning to use the theory to focus on the experiential aspect of recreation.

Recreation demand theory is hierarchial in nature and is based on the premise that visitors will seek out a recreational experience that will maximize their physical and psychological well-being. Figure 1 shows a four level version of the recreation demand hierarchy. Level 1 is the demand to participate in a specific activity. Level 2 involves participation in a setting that offers the social, resource and managerial attributes desired. Level 3 is the psychological satisfactions (such as learning more about nature) obtainable from activities that require interaction with selected park attributes. Level 4 is the demand for various long-term benefits such as better job performance or increased family togetherness. The realization of level 4, long-term, benefits is dependent on how well the visitor's desires for the first three levels have been met.

A simple example is that of a person who travels to the Grand Canyon to participate in hiking and viewing canyon rims (demand level 1). While engaging in these activities the individual might prefer that the air be clean and free of pollution and the trails not be crowded (demand level 2). By engaging in the desired activities in a recreational setting that contains the attributes deemed important, the individual experiences psychological satisfactions such as experiencing nature and solitude (demand level 3). A long-term benefit that might come from participating in the desired activities with the desired attributes present and with the desired psychological satisfac-



RECREATION DEMAND HIERARCHY

Figure 1. *Recreation demand hierarchy*

11. Below are Park features that were listed in Question #9 which can affect your recreation experience. Now for each feature listed below, **circle the number** which indicates how important each feature was to your recreation experience.

	Park Features	Not at All Important	Slightly Important	Moderately Important	Very Important	Extemely Important
1.	Information about the park	0	+1	+2	+3	+4
2.	Interpretive signs	0	+1	+2	+3	+4
3.	Park visitor facilities	0	+1	+2	+3	+4
4.	Hiking trails	0	+1	+2	+3	+4
5.	Park naturalists/rangers	0	+1	+2	+3	+4
6.	Naturalists' program	0	+1	+2	+3	+4
7.	Cleanliness of park	0	+1	+2	+3	+4
8.	Bus shuttle system	0	+1	+2	+3	+4
9.	Views of the river	0	+1	+2	+3	+4
10.	Viewing distant rock formations outside the park	0	+1	+2	+3	+4
11.	Haze within canyon	0	+1	+2	+3	+4
12.	Haze on the horizon	0	+1	+2	+3	+4
13.	Viewing canyon rims	0	+1	+2	+3	+4
14.	Sunrises or sunsets	0	+1	+2	+3	+4
15.	Clouds within canyon	0	+1	+2	+3	+4
16.	Cloud-covered sky	0	+1	+2	+3	+4
17.	Colorful rock formations	0	+1	+2	+3	+4
18.	Deep gorges	0	+1	+2	+3	+4
19.	Unusually shaped rocks	0	+1	+2	+3	+4
20.	Backcountry permit system	0	+1	+2	+3	+4
21.	Campground reservation system	0	+1	+2	+3	+4
22.	Clean, clear air	0	+1	+2	+3	+4
23.	Variety of flowers, shrubs, and trees	0	+1	+2	+3	+4
24.	Variety of birds & animals	0	+1	+2	+3	+4

Figure 2. *Attributes and response format used to determine visitor ranking of importance for various park attributes.*

tions realized could be enhanced work performance (demand level 4).

The key to effective management in terms of the recreational experience is to manage for the first and second levels of the hierarchy. For example, certain activities can be allowed only in specified areas of the park or must be prohibited throughout the park. (Level 1) It is also possible, although more difficult, to manage park attributes (such as good visual air quality), that are important to park visitors. (Level 2) Managing for the third and fourth levels of the hierarchy is more difficult because these levels are abstract. However, levels 3 and 4 can be provided for indirectly through appropriate management of demand levels 1 and 2. If the activities desired and the attributes deemed important are present at the park area, and if visitors are highly satisfied with the quality of each, the third and fourth levels of demand are more likely to be realized than in a case where desired aspects of levels 1 or 2 are not present or are perceived to be of poor quality.

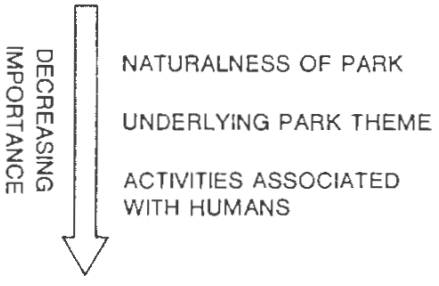


Figure 3. *"Clustering" of preferred attributes shown here in order of visitor preference.*

Four National Parks Surveyed

A basic step, then, in maximizing the recreation experience is to understand which park attributes the visitor feels are most essential to a positive experience. To examine the importance of park attributes to the visitor experience (demand level 2), mail-back surveys were used to collect data at Grand Canyon, Mesa Verde, Mount Rainier and Great Smoky Mountains NPs during the summers of 1983 and 1984. Figure 2 shows the attributes and response format used at Grand Canyon. While the list of attributes varied among parks, the response format used was the same at all parks.

Cluster analysis was used to determine if clusters, or groups of park attributes, could be identified based on visitors' responses to the importance of attributes. This analysis was performed not only to reduce the large number of variables involved, but also to determine which park attributes belong to certain "domains" of attributes in the visitors' minds. For example, it might be expected that attributes about park management could be clustered into one group, while attributes about the park's natural resources would cluster into another group. Results showed five clusters of attributes at Grand Canyon and Mesa Verde, and three and seven clusters of attributes at Mount Rainier and Great Smoky Mountains respectively.

The analysis yielded a number of trends. First, a cluster of attributes was identified at all parks that could be asscciated with natural environments undisturbed by humans. Attributes included in this cluster were "Clean, clear air," Clean, clear water" and "Cleanliness of the park." For lack of a better term, this set of attributes will be referred to as the "naturalness cluster." This cluster ranked as most important at all four parks.

Secondly, the cluster analysis suggests that the second most important set of attributes is associated with the underlying theme for which the park is famous; the least important clusters consisted of attributes associated with human activities (see Fig. 3). For example, while naturalness was the most important cluster of attributes at both Grand Canyon and Mesa Verde, a view related cluster at Grand Canyon and an information related cluster (which emphasized park history) at Mesa Verde ranked as the second most important cluster of attributes at those parks, respectively. In the least important clusters were attributes such as "backcountry reservation system," "guided tours," and "shuttle bus systems." As a general hypothesis, it is suggested that visitors to national parks feel that a natural environment, free of pollution and undisturbed by humans is most important to their experience, and the underlying theme of the park is second most important.

Data also were collected at Grand Canyon and Mesa Verde, using on-site interviews, to examine what effect visual air quality might have on the recreational experience sought. Visitors were asked to judge their awareness of haze and the effect haze might have on their enjoyment of the visual resource. They also were asked to indicate whether they thought the haze was man-made or natural.

Results of this portion of the study showed that at Grand Canyon 76 percent of the visitors interviewed indicated they saw haze and at Mesa Verde 86 percent of the visitors interviewed thought they saw haze. Comparisons of visitor awareness of haze at the Grand Canyon and a physical measure of the actual visibility at the time of the interview showed that changes in visitor awareness of haze corresponded to changes in visual air quality (see Fig. 4). As visitors said they became more aware of haze, their reported enjoyment of the view and their satisfaction with visual air quality decreased. Of the visitors who said at the interview they saw haze, 80 percent and 83 percent at the Grand Canyon and Mesa Verde, respectively, felt the haze was natural. The results of these studies have several implications for park management.

If the park areas are to be managed in a way that will allow visitors to maximize their sense of well-being, these findings suggest that special attention should be paid to preserving the resources that make up the naturalness cluster. Visitors are primarily seeking a recreational experience in an environment that is natural, free of pollution, and undisturbed by humans.

It also is important to emphasize that the visitors' perceptions of how much haze is natural or man-made is in direct contradiction to actual measurements at these parks. While 80 percent or more of visitors think the haze is natural, monitoring programs show that 60 percent to 80 percent of the haze is associated with urban and industrial sources. Since the majority of visitors feel that haze in national parks is natural, when in reality it is mostly man-made, we suggest that interpretation and education programs proceed to inform the public of the reality and of possible resource consequences that could occur with the transport of pollutants into national parks.

Ross is a Research Social Scientist with Air Resource Specialists, Inc., Fort Collins, CO; Malm is Research Physicist with the NPS Air Quality Division in Fort Collins.

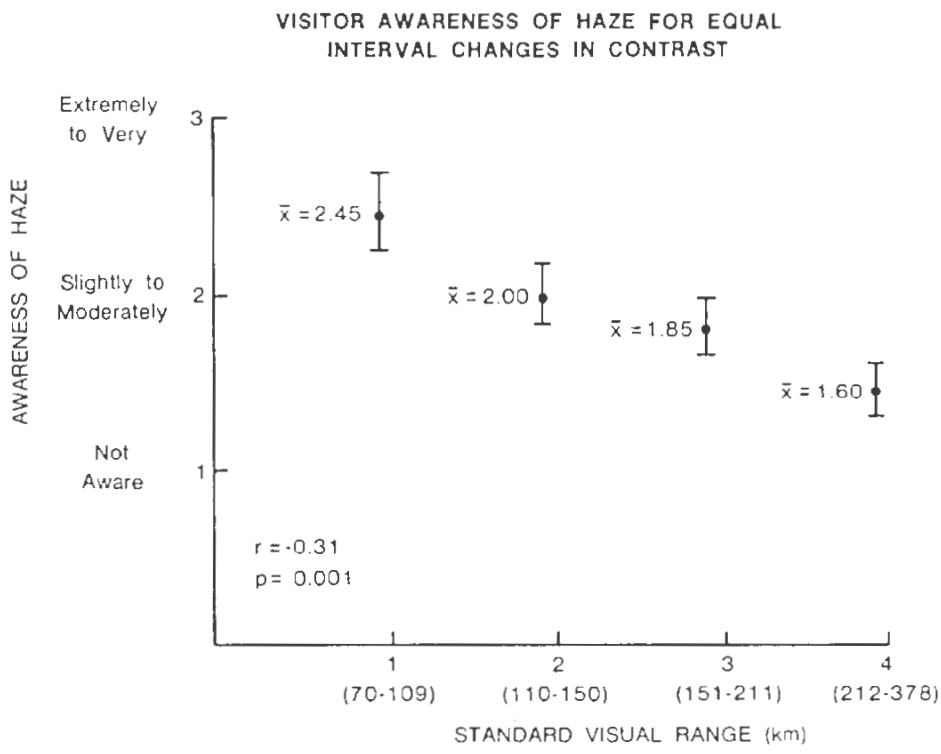


Figure 4.

Trail Logs Reveal Visibility Impact On Park Visitors

By Ross J. Loomis and Douglas Garnand

Sometimes comments overheard, written in a guest register or volunteered to a staff member provide important insights into how people feel about a setting they are in. The more spontaneous and unsolicited the comments, the more they are apt to represent unselfconscious, honest opinions. Even visitor logs or comment cards, though a form of request, can sometimes elicit candid reactions. In their book, *In Search of Excellence*, Peters and Waterman report that J. Willard Marriott Sr., of the hotel chain that bears his name, made a point of reading every guest complaint card. Marriott knew the value of good customer service and keeping up with guest comments provided him with a source of information about the reactions of people staying in his hotels.

Comments, whether complaints or compliments, can reveal to management how visitors perceive and feel about specific features in the park. Those features can range from the cleanliness of restrooms to the courtesy and helpfulness of staff who interact with visitors. Comments also can let management and staff know how visitors feel about basic park attributes such as visibility and show how visitor awareness of different conditions of air quality can change the nature of visitor experience in the parks.

The NPS conducts research on air quality through the Air and Water Quality Division, an essential part of whose studies is the monitoring and assessment of the physicial change in air quality at different park locations. That work has been augmented by some research on the human aspects of air quality, such as how sensitive the eye-brain system is to different kinds of haze formations that could appear in a vista scene. Other work on the human response to visibility in the parks has involved surveying visitors at vista points in the Grand Canyon and Mesa Verde parks. That work employed interviews and questionnaires that asked visitors such questions as how visibility figured in the context of their enjoyment and satisfaction.

Researchers know that asking survey questions puts a demand on people that may influence how they respond. Comments overheard, entries in visitor guest books, and comments or questions volunteered to staff tend to be free of interviewer or questionnaire demand bias. These alternatives to formal survey procedures are sometimes called "unobtrusive measures," measures that are a more natural part of the setting. Visitors ask questions or make written comments in a visitor log as a natural part of their visit.

Typically, unobtrusive measures are used to validate or check the outcomes of more formal measures, such as interviews. Spontaneous comments will either substantiate what has been found in surveys or point out problems and reactions that, for one reason or another, were not mentioned in the interview or questionnaire assessments. Any lack of consistency between formal and unobtrusive measures can suggest the need for additional work to clarify what is the best measure. In the case of visitor-based visibility research, we had learned from the Grand Canyon survey data that visitor awareness of haze was related to how far they could see as indicated by a measure of Standard Visual Range (SVR). As SVR decreased there was an increased likelihood that visitors would report seeing haze on a vista in answer to interview questions about visibility. Was this relationship just due to the demand quality of the interview? Were we sensitizing people to haze by interviewing them about visibility?

Voluntary information *about visitor sensitivity to air quality and how visibility affects the visitor experience is often found as commentary in the visitor registration forms.*

To answer these questions we asked that visibility related information be kept on the ranger report logs for a couple of major hiking trails at the Grand Canyon. Rangers were not to ask visitors about visibility, but were to record the number of times different visitors on the trail made positive or negative comments about visibility. Park staff were helpful in collecting this visibility information as part of routine reporting of trail use and problems. The trail logs were recorded across the days of summer 1983 and the number of visibility related comments tabulated.

The first thing we noticed about the log data was that most days no visibility related comments were recorded during the rangers' trail patrol. That finding was hardly exciting for the visibility researchers! But visibility was quite good during the summer period and so it was not surprising that only infrequent comments were heard.

When the comments were looked at on a day-by-day basis, an interesting pattern appeared. On very clear days, a few positive comments showed up on the logs. Hikers were impressed with being able to see long distances and would comment to a ranger. For the days when SVR was the lowest for the summer, negative comments appeared, and in some cases, 15 to 20 comments were made in a single day. These negative comments often were in the form of questions about why it was hazy or if it was always this hazy. Sometimes hikers were sufficiently impressed by visibility conditions to comment on what they had noticed the day before. Because visibility impairment can occur in cycles and last a few days, it was not surprising that negative comments usually came in groups across a short time period. What made the trail log data on visibility especially meaningful was that visibility was only one of many, many park attributes hikers could comment on. It helped to validate the survey interview results from other visitors that hikers seemed most likely to comment on visibility when SVR dropped and haze conditions increased.

Park personnel also kept visibility comment logs at two specific locations where it would be expected that people would engage in viewing distant features and might make comments about visual quality. Once again, staff were to record unsolicited comments only, and tally both positive and negative comments. In addition, staff were to record the substance of comments.

One location was the museum at Grand Canyon where visitors could look through the windows to the other rim of the canyon. Results from this log were similar to the trail logs. On many days, there would be no visibility related comments at all; on a few days, some positive comments would be made about the wonder of the view; on yet other days, several negative comments would appear. Visitors would ask why it was hazy, others would assume that it was natural fog or mist, while still others would announce that the haze must be pollution. Some visitors commented that the haze upset their plans to take pictures; others noted that the haze seemed to change the color of canyon features.

The other location used to collect unsolicited comments was the Firetower at Mesa Verde. At this location visitors can see a view out of the park that includes both the landmark shiprock formation and a power plant. Visibility comments, both positive and

Give Us Park Rangers To Match Our Grasshoppers

By Mark Wagner

WHEN your visitors from afar are too frightened to get out of their car, who do you call?
GRASSHOPPER BUSTERS!

WHEN the farmer down the block needs some help to save his crop, who do you call?
GRASSHOPPER BUSTERS!

WHEN you can't get to the door 'cause they're coverin' the whole floor, who do you call?
GRASSHOPPER BUSTERS!

WHEN the railroad tracks are slick from the grasshopper grease that's thick, who do you call?
GRASSHOPPER BUSTERS!

"Promontory, May 1869. The town consisted of a few tents, the ticket houses of both companies, their telegraph offices, hordes of grasshoppers, and swarms of sand fleas." So goes the description of Promontory 116 years ago. Today, the town is gone, but the grasshoppers are back for another visit.

The situation at Promontory this past Spring was getting out of hand. Grasshoppers were covering everything. The walkway to the visitor center was (literally) a writhing mass of brown and green. The more courageous visitors were carrying the less courageous ones from their cars and into the building. Every morning the grasshoppers were piled up 50 thick in front of the doors. People were afraid to enter the restrooms for fear of attack. One brave caller even found a grasshopper in the pay phone coin return!!

The park began to get some pressure from the farmers nearby. You see, Golden Spike is a park 15½ miles long but only 400 feet wide (the historic railroad grade of the Pacific Railroad) and lies in the heart of rich wheat farming country. The snake-like shape of the park meant that Golden Spike was a strip of land where the hoppers could multiply without the worry of insecticides. So, the hoppers began to commute from Golden Spike to the wheatfields for the day and back to the park at night. Golden Spike had become a grasshopper bedroom community!

It was definitely time to call GRASSHOPPER BUSTERS! Park rangers donned their "buster suits" quickly and took to the offensive. Because the grasshoppers were getting into the visitor center and eating all the house plants (not to mention creating havoc for anyone wearing shorts in the dark auditorium), a first course of action was to place a "NO GRASSHOPPERS" international symbol sign on the entry doors. A written sign was not used because grasshoppers are believed to be illiterate.

Next, the entry way needed to be cleaned up and grasshopper-proofed. An intensive hourly sweeping program was initiated, but the grasshoppers were quickly gaining. GRASSHOPPER BUSTERS realized that the hoppers had to be removed for good; it was time for drastic action. The dry-vac was brought from the wood shop and the green and brown troublemakers were quickly sucked into oblivion! But even so, the hordes continued to converge on the shady pathway and the vacuum was set aside as inadequate.

It was time to get a good look at the enemy and get a fix on what kind of numbers were really "out there." So, a one square yard frame was constructed that would allow GRASSHOPPER BUSTERS to count the enemy more accurately. The frame proved ineffective – the incredible numbers were impossible to count as the grasshoppers jumped in and out of the frame. Back to the drawing board. GRASSHOPPER BUSTERS put sides on the frame, a small opening on one end, and christened the new contraption the "Lazy G Grasshopper Corral and Roundup."

When put into place one GRASSHOPPER BUSTER herded the hoppers through the opening while the other counted the escaping enemies. Initial counts were shocking . . . 80 per square yard . . . 113 per square yard . . . and, in a particularly green area, 338 grasshoppers per square yard!! With counts like these, even GRASSHOPPER BUSTERS had doubts about their chances. With consultation, approval, and financial support from the Rocky Mountain Regional Office, it was decided to bring in the granddaddy GRASSHOPPER BUSTER of them all – *Nosema locustae*, a protozoan grasshopper spore disease which affects only grasshoppers and spreads through the population by cannibalism. This was no longer war . . . this was biological warfare!

The *Nosema* spore was mixed in liquid form and sprayed onto wheat bran. The bran was then broadcast on park property from a fixed wing aircraft.

Local land owners were pleased that GRASSHOPPER BUSTERS at Golden Spike were taking serious action. They showed interest in the utilization of biological control, but themselves chose to spray chemical insecticides, which would bring immediate results. The *Nosema* would take several weeks, but the contest was on!

GRASSHOPPER BUSTERS now turned to their plots and began taking weekly counts. If *Nosema* was working, the grasshopper numbers would start to decline. It took a few weeks, but the numbers started to drop . . . significantly. The plot with the very high density showed 73 live and 41 dead after two weeks. One month later, the same plot had 7 live and 42 dead grasshoppers. It looked like a rout for the granddaddy GRASSHOPPER BUSTER. Needless to say, the farmers fell in love with the Golden Spike GRASSHOPPER BUSTERS, especially granddaddy *Nosema*.

Counts will continue into next year. The *Nosema* disease inhibits egg laying in the Fall, and is passed on to the next generation in the egg pods.

With August here at Promontory no one is talking about grasshoppers. There simply are not many around any more. The hoppers are supposed to be just as bad next year, but GRASSHOPPER BUSTERS will be here to keep an eye on them. But for now, gosh . . . does anyone know a good MOSQUITO BUSTER?!

Wagner is a Ranger at Golden Spike National Historic Site, Brigham City, Utah.

Trail Logs Continued

negative, were more frequent at this location and were logged on most days. The Mesa Verde Firetower log was kept for only 20 days during the 1983 summer. On these 20 days, however, nearly 200 unsolicited comments about visibility were logged by the ranger on duty, with negative comments outnumbering positive by almost three to one. Actual visibility varied considerably across the 20 days and visitor comments changed with different visual quality conditions. More visitors commented about pollution at this location, probably because they could see the power plant and also specific smoke plumes from fires burning in the region. One aspect of visitor comments about visibility that becomes apparent from the Mesa Verde logs is that visitors do try to determine if haze seen is caused by natural or human events.

Visitor comments from all three sources mentioned in this paper revealed concern over loss of opportunity on days of reduced visibility. This pattern in the log data was consistent with survey findings that impaired visibility can reduce visitor enjoyment. These results help us document that visitors do regard visibility as a natural resource. If that resource is diminished, it is realistic to expect visitors to notice the change and become increasingly criticial about the loss of visibility. It is difficult for most visitors to know what produces changes in visibility and it is reasonable to expect that on days of impaired visibility visitors will inquire as to why things look the way they do.

The kind of unobtrusive measures described in this paper should not be used by themselves. Coupled with more sophisticated methods such as visitor surveys, they provide a significant source of information about what is happening to the visitor with relation to visibility. The comments help park staff keep in touch with their visitors and researchers to better understand the experience of park visitation.

Loomis is a professor of psychology at Colorado State University, Fort Collins, CO; Garnand is a graduate student in the CSU department of psychology.

Rotating Resource Base Program Gets Western Tryout

By Thomas M. Gavin

A new entry into the resource management field, referred to as the Rotating Resource Base (RRB) program, implemented in FY 1985 by Western Regional Director Howard Chapman and funded for $50,000, was established under management of the Division of Natural Resources and Research. Distribution of funds to Western Region field areas is based on meeting all of the following project criteria:

1. Projects are critical to restoring processes or eliminating threats to ecosystems or other park resources.
2. Projects are small – of limited scope or intent.
3. Projects are non-recurring and can be completed in one year.
4. Lack of flexibility in the park's budget necessitates provision of base funding for the project.
5. Project is low budget, generally requiring $6,000 or less.
6. Project was either proposed or referred to in the approved Natural Resources Management Plan (NRMP).

This program is designed to supplement other resource management funds which, in the past, have seemed to emphasize only the most competitive, complex, and expensive resource management projects typical of the larger and/or more heavily visited parks. As with similar programs, a comprehensive list of project proposals was ranged according to priority by the Regional Office staff. The following were funded and completed in FY 1985:

1. Fort Bowie National Historic Site: Control of mesquite vegetation, which threatens cultural resources.
2. Walnut Canyon National Monument: Study to determine and restore historical water flow through the park.
3. Tonto National Monument – Elimination of honey-bee threat to visitors at the cliff dwellings.
4. Montezuma Castle National Monument – Elimination of exotic Asiatic clams.
5. Coronado National Monument – Removal of graffiti from cave resources.
6. Joshua Tree National Monument – Construction of a greenhouse to be used in borrow pit and old road rehabilitation.
7. Lava Beds National Monument – Burning and reseeding to native vegetation for wildlife habitat improvement on NPS acreage adjacent to Tule Lake National Wildlife Refuge.
8. Saguaro National Monument – Hazard fuel reduction burn at historic Manning Camp.
9. Whiskeytown National Recreation Area – Hazard tree removal in and around park developments, including mechanical removal and the use of prescribed fire.
10. Organ Pipe National Monument – Improvement of water line to Quitobaquito Oasis to maintain historic flow from spring to pond and enhancement of the current pupfish populations.
11. Hawaii Volcanoes National Park – Repair of goat fence.
12. Point Reyes National Seashore – Removal of Coast Creek dam to restore anadromous fish populations.

Although all funding allocated for the program ultimately was obligated in field areas, $6,000 was withheld within the Regional Office until August, as a contingency fund for emergency resource management needs as they might occur throughout the year. Although this feature of the program was not needed in FY '85, it will be utilized in the future and will allow for flexibility and management discretion to be exercised by the Western Region Division of Natural Resources and Research.

In retrospect, the RRB Program is seen by the Western Region as a great success. A review of the program this year determined that the qualitative cost/benefit ratio used to evaluate program effectiveness increased with the completion of each funded project; the benefits of completing the proposed work have far outweighed the cost with respect to improved morale of field managers and reduction of Resources Management Plan project backlogs. The projected costs of many proposed projects displayed in Resources Management Plan project statements were reduced from original estimates by managers who used innovative tactics and/or volunteer labor. Contributing to the overall success of the program was the funding of project proposals oriented toward *immediate mitigation* of a problem. Thus, a highly visible display of resources management accomplishments was established Regionwide.

Gavin is NPS Western Region Plant/Fire Ecologist, Division of Natural Resources and Research, Box 36063, San Francisco, CA 94102.

NPS/GW Society 1986 Conference Abstracts Call

"The Interrelationship of Man and the Environment," theme of the NPS/George Wright Society Science Conference on Research in the National Parks, (July 13-20, 1986, at Colorado State U., Fort Collins) is directed at furthering the dialogue between scientists and resource managers directly involved in the application of science and technology to cultural, natural, and recreational resource functions. Forty-five topical sessions have been developed, covering the cultural, physical, social and biological sciences, and natural, cultural and urban resource management.

Abstracts are due immediately and should be sent to Ray Herrmann (natural sciences chairman) or Calvin R. Cummings (social sciences chairman) at 339 Aylesworth Hall, N.W., Colorado State U. Fort Collins, 80523. Phoned information can be had at (303) 491-7573 or 221-5341.

Abstracts should be original camera ready, 250 words or less, and typed in prestige elite transcript on 8½x11" paper with 1" margins. Sample formats can be obtained from either Herrmann or Cummings.

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PRESCRIBED BURNING IN THE MIDWEST: STATE OF THE ART

This symposium, to be held March 3-6, 1986, at Stevens Point, Wisc., will focus on the technical applications of fire in central and eastern North America. Contributed papers are being sought. Persons interested should send a one-page, single-spaced, camera-ready abstract to Al Simard, North Central Experiment Station, 1407 South Harrison Rd., East Lansing, MI 48823. Those interested in the poster session should send a separate abstract to Duane Duper, Wisconsin Dept. of Natural Resources, P.O. Box 7921, Madison, WI 53707. For registration information, contact Andi Koonce, College of Natural Resources, University of Wisconsin, Stevens Point, WI 54481 or call (715) 346-2269.

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INDIANA DUNES RESEARCH CONFERENCE

Scheduled for May 1-3, 1986, this conference is being sponsored by the Indiana Dunes National Lakeshore, Indiana Academy of Science, Indiana Northwest, and the Indiana Dept. of Natural Resources. The conference will include symposia on succession, shoreline erosion, and visitor aspects of resource management; contributed paper sessions; and a natural areas session including field trips to many unique habitats in northwest Indiana. Those interested should contact Ron Hiebert, Indiana Dunes National Lakeshore, 1100 N. Mineral Springs Road, Porter, IN 46304.

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NORTH AMERICAN PRAIRIE CONFERENCE

The tenth biennial North American Prairie Conference will be held in 1986 at Texas Women's University June 22-26, in Denton, Texas, near Dallas. Theme of the conference is "North American Prairie: The Roots of Our Culture, The Foundation of Our Economy." Persons interested in presenting a paper or conducting a panel session should immediately submit an abstract to Program Committee, Native Prairie Association of Texas, Texas Women's University, P.O. Box 22675, Denton, TX 76204.

Book Reviews

S.T.A. Pickett and P.S. White, 1985. The ecology of natural disturbance and patch dynamics. Academic Press, Orlando, San Diego, New York, xiv, 472 pp.

Over the last two decades, park managers have become increasingly aware of the importance of natural disturbance regimes within parks. Natural preturbations, such as fires, floods and landslides are no longer feared as adverse events, but are considered critical to the maintenance of both unique species and successional biotic communities. Pickett and White have assembled a selection of review papers, covering plant and animal responses to disturbance and the major types of ecosystem change. Some of the discussions report work from park or reserve areas. James Runkle's "Disturbance in temperate forests," for example, describes the effect of tree fall in the Great Smoky Mountains. Other discussions touch on topics of high interest to contemporary managers. Norm Christensen, for instance, has prepared a review of "Shrubland fire regimes and their evolutionary consequences." Although a majority of the papers concentrate on forested ecosystems, the habitats discussed vary from rocky intertidal shores to deserts of the southwest.

Pickett and White have done a commendable job, both in selecting the papers and in editing them. The papers integrate theoretical issues with field data, and include two overviews that summarize the contents of the volume. The general bibliography at the end of the book serves as a valuable master list of the best available references on disturbance ecology.

For the ecologist working on patch dynamics or succession, the volume presents several stimulating discussions of contemporary disturbance theory. Part IV, on "Implications of patch dynamics for the organization of communities and the functioning of ecosystems," includes reviews of disturbance mediated coexistence of species, nutrient dynamics, energetics and forest modeling.

The book points out the importance of two current hypotheses concerning disturbance: 1) ". . . species richness will be greatest in communities experiencing some intermediate level of disturbance" and 2) "When disturbance recurs more frequently than the time required for competitive exclusion, richness should be maintained . . ." but leaves the basic issues in an uncertain state. The volume produces more questions than answers. Through several discussions of gap-phase succession, for example, the question of whether tropical forest species are "adapted to gap regeneration" or are reproductively "haphazard with regard to gap conditions" remains undecided.

Despite the value of the book to the research scientist, the manager should be warned that the book may be difficult to use for direct application to park problems. First, the text is written at graduate level and assumes a knowledge both of basic theoretical ecology and of the technical vocabulary used in ecological journals. Some chapters, such as the one on shrubland fire, will contain familiar ideas. Others, such as the one on forest modeling, may present so much new material they may be difficult to decipher. Second, although Pickett and White briefly discuss management and some of the chapters are directly relevant, *The Ecology of Natural Disturbance and Patch Dynamics* makes it all too clear that much of this new theory has yet to be applied by managers, and that further translation will be necessary to make some of the key discoveries of the last ten years useful for decision making in parks.

Pickett and White themselves admit that disturbance ecology lacks coherent theory, and no general principles exist that can be safely applied from one ecosystem to the next or from one species to the next. This deficiency may well be limiting practical applications. Science activities within the National Parks should, in fact, help convert results from natural history studies into useful tools for managing disturbance in wildland settings. It is encouraging to see Peter White, as a National Park Service scientist, doing trend-setting work in both theoretical and applied plant ecology.

In summary, ecologists working with perturbations of natural ecosystems and large parks with numerous management issues concerning disturbance processes will find the volume a valuable reference to add to their libraries. Park managers may wish to borrow a copy of the book and devote time to chapters relevant to their areas, but will probably find some of the discussions to be of little local interest or too theoretical to apply to immediate problems.

Susan P. Bratton, Unit Coordinator, NPS/CPSU
Institute of Ecology, University of Georgia,
Athens, GA 30602

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Park management personnel, especially those who deal with the natural resource development adjacent to parks, should be aware of a book by Raymond L. Gold, reviewed by Craig R. Humphrey in the Oct. 4, 1985 issue of *Science*, (Vol. 230, pp. 58-9). In *Ranching, Mining, and the Human Impact of Natural Resource Development* (Transaction Books, Rutgers U. New Brunswick, NJ, 1985, 175 pp. $24.95), Gold analyzes a mythical town of Sagebrush, pseudonym for the many small western towns in which Gold has worked during the years of energy shortage and corporate development of energy sources – sometimes with and sometimes without bringing the residents of these towns into the corporations' confidence and their developmental equations.

Perhaps most interesting is the question Gold leaves dangling: Why do executives of energy production companies engage in contentious natural resource development instead of going the accommodative development route, if (as experience shows) this strategy results in conflict, production delays, high turnover of the labor force, and lower labor productivity? Reviewer Humphrey (Penn State U Dept. of Sociology and Science, Technology, and Society Program) says: "Gold set out to identify theoretically and practically important facets of social change occurring in small towns with large-scale energy production systems in progress, and he has done so in a sophisticated and telling way."

Book Examines Threats To Parks of the World

The State of the World's Parks, an international assessment for resource management, policy, and research, by Gary E. Machlis and David L. Tichnell, was published in October 1985 by Westview Press (5550 Central Ave., Boulder, CO 80301) in cooperation with the World Wildlife Fund and the National Park Service.

The book examines two questions: What are the threats to national parks worldwide, and what can be done about them? This is the first systematic, international study of the pressures faced by the more than 1,000 national parks around the world.

The authors borrow from the disciplines of ecology, anthropology, and sociology, as well as from the applied fields of wildlife management, park management, and environmental science. Their arguments are based on data collected from a survey of 135 parks in more than 50 countries; the voices of park managers, conservation officers, and game wardens are heard throughout the book.

Recommendations, some controversial, are made for resource management, policy, and research. With an Introduction by Hal Eidsvik, *Threats* has 147 pages with tables, figures, notes, bibliography, appendixes, and index. An introductory 20% discount offer puts the price at $23.

information crossfile

A Forest Service publication for sale by the Superintendent of Documents in Washington, D.C., is *The Seen and Unseen World of the Fallen Tree*, edited by Chris Maser and James M. Trappe. The 56-page book, illustrated in both color and black and white, treats the contribution to forest ecosystems of the decay of large, fallen trees. The publication, with its cover drawing of an ant's view of the seedling moss, lichen, and mushroom cover on the surface of a fallen class III Douglas fir tree, is excellent source material for interpretation of forest areas, especially in the West.

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Forestry Research West, in its October 1985 issue, carries two articles of interest to park managers. "Beavers: Biologists 'Rediscover' a Natural Resource," explores the pivotal role of the beaver as "a skilled, hardworking assistant in the repair and stewardship of riparian ecosystems." Based primarily on the work done by Ecologist Jim Sedell of the Pacific Northwest Forestry Sciences Lab in Corvallis, Ore., the article examines new information about the effect of beaver activities on nutrient cycling.

"We're looking at fish habitat in ways that don't stop at the water's edge," Sedell says. "We're finding that beavers have dramatic effects on streamside vegetation that benefit a whole range of creatures besides fish."

Mike Prouty of the USDA Intermountain Station, examines the research of Forest Service Scientist L. Jack Lyon and asks the question: "Are (Rocky Mountain) elk and modern man compatible?" The article is entitled "Wildlife Research: Separating Fact from Fiction," and describes the history and findings of 15 years of cooperative elk research by six different organizations. Publication of the study findings is titled "Coordinating Elk and Timber Management. Final Report of the Montana Cooperative Elk-Logging Study 1970-1985; the report is available from the USDA/FS Forestry Sciences Lab, PO Box 7669, Missoula, MT 59807.

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An article on "Acid Deposition, Smelter Emissions, and the Linearity Issue in the Western United States," in the Aug. 30, 1985 issue of *Science*, reports data that support a linear relation between emissions and sulfate concentrations. The work, by Michael Oppenheimer, Charles B. Epstein and Robert E. Yuhnke, all of the Environmental Defense Fund, Inc., compares the variation in sulfur dioxide emissions from nonferrous metal smelters in the western United States over a 4-year period with the variation in sulfate concentrations in Rocky Mountain states precipitation. The geographic separation of emissions sources and precipitation monitors indicates a sulfur transport scale exceeding 1,000 kms.

The same issue of *Science* (Vol. 229, p. 1070) contains a review by Eliot Marshall of a major acid rain study released on Aug. 29, 1985, by the Environmental Protection Agency. Charles Elkins, the acting air and radiation chief at EPA, called it "the first page in the first chapter" of a long book. It is the first information to come out of the National Surface Water Survey, a $6 million project begun by former EPA Administrator William Ruckelshaus. The study describes the acidity and alkalinity of unpolluted waters east of the Rockies as reflected in a one-shot random sample of 1,620 lakes in the fall of 1984. A similar study of western lakes began in August 1984.

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***The EYAS*, newsletter** for the Institute of Wildlife Research's Raptor Information Center, carries in its Winter 1985 issue (Vol. 8, No. 1) a letter from David Manuwal, University of Washington College of Forest Resources professor, urging a new owl survey. Manuwal cites new information from the state of Washington, indicating that pressures on the Spotted Owl in that state may be different from those in areas previously studied, and stating that present knowledge of competitive and predatory relationships as well as other ecological factors "is totally inadequate."

The spread of Barred Owls and Great Horned Owls in Washington, especially in harvested areas, is creating greater interest in national parks as research control areas, according to Pacific Northwest Regional Chief Scientist Jim Larson.

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Arctic (Vol. 38, No. 3), September 1985, carries a seven-page article by John G. Dennis (NPS/WASO), Charles H. Racine (Johnson State College, VT), and William A. Patterson III (U/Mass, Amherst), on "Tundra Fire Regimes in the Noatak River Watershed, Alaska: 1956-83." The research covers location, cause, frequency, size, rotation times, and seasonal timing of tundra fires in the Noatak River watershed as determined from BLM fire records and satellite imagery. The article discusses the implications of seasonal timing (all fires occurred during one of two summertime periods in June and July) and compares the fire regimes of the Noatak with those of other areas in northern Alaska.

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A good deal of space in the national press has been given over recently to the discovery of eastern brook trout – *Salvelinus fontinalis* – in Arnica Creek near West Thumb Bay of Yellowstone Lake. (Supt. Bob Barbee offered a $1,000 reward for information on the person responsible for putting the brook trout in the creek, and warned that a $5,000 fine and five years in prison is the maximum punishment faced by the guilty party). The eastern trout intrusion could mean extinction for Yellowstone's native trout species, the cutthroat – a valued sport fish – and could throw a monkey wrench into nature's food chain, with dangerous consequences for nonaquatic Yellowstone fauna.

A report on countermeasures by NPS and Fish and Wildlife Service personnel is being readied for *Park Science*.

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A statewide beach clean-up project with the emphasis on wildlife protection has won a national award from Keep America Beautiful, Inc., for the state of Oregon. More than 2,100 volunteers met on the stormy ocean beaches on Oct. 13, 1984, and collected 26.3 tons of plastic debris from the 310-mile shoreline – an effort that was surpassed in the fall of 1985. Judie Neilson of the Oregon Department of Fish and Wildlife observed that "this is not an anti-litter campaign. It is designed to call attention to the threat marine debris has to wildlife either through ingestion or entanglement."

Similar clean-ups were mounted this year by other Pacific, Atlantic and Gulf coastal states as a result of the first Oregon project.

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Nearly 1,000 miles of Oregon coastal streams are the subject of a five-year stream improvement program by the Bureau of Land Management, with the major effort being to substitute for the key missing element – the large old-growth tree trunks or woody debris so important to production of salmon and steelhead. In the past, so-called "corrective actions" have meant clearing debris and barriers from streams where logging and roadbuilding had taken place. The BLM's recently released "*Five-Year Comprehensive Anadromous Fish Habitat Plan for Oregon Coastal Rivers*" notes:

"Historically, there were many fallen, large, old-growth trees (trunks or parts) in Oregon's coastal streams that created some of the best spawning and rearing areas for young salmon and steelhead. The significance of this natural occurring large woody material to anadromous fish productivity was not fully recognized until recent years." BLM will spend more than two million dollars over the next five years to recreate the conditions eliminated by past "corrective actions."

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From Tom Lucke, Chief, NPS Water Resources Division in Fort Collins, Colo., comes the note that the Natural Resources Law Center produces a publication entitled *Resource Law Notes*, which contains articles and information on Natural Resources legislation and policy. A subscription is available without charge. You can be placed on the mailing list by writing to:

Editor, *Resource Law Notes*, Natural Resources Law Center, University of Colorado, School of Law, Boulder, CO 80309-0401.

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The summer 1985 issue of *Renewable Resources Journal* (Bethesda, MD) contains an article by Anthony S. Earl, Governor of Wisconsin, entitled "Lessons from Germany in Controlling Acid Rain." The article is adapted from his speech before the Intergovernmental Conference on Acid Rain in Quebec, April 11, 1985.

The U.S. EPA and the National Acid Precipitation Program National Lake Survey, Phase II, now is being implemented for the northeast U.S. Phase II will evaluate chemical variability and biological status for a select set of lakes and streams and follows a Phase I synoptic survey of lake and stream chemistry presently being implemented in the west. A planned Phase III will establish a small number of long term monitoring sites, similar to previous and ongoing NPS efforts, to quantify future changes in the chemistry and biology of geographically representative aquatic ecosystems.

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Countryside Commission News, produced by England's Countryside Commission, is published every two months and offers an excellent way to keep abreast of what is happening in English parks and protected areas. It is distributed free to national parks, research and academic institutions, and other interested parties. The latest issue contained an

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Visitor Advocate: A Novel Management Strategy

By Jean A. Merriman

For some time, I have had the gnawing feeling that all was not quite well in paradise. Today's specialization, operational complexity, and endlessly competing demands on everyone's time to police and service our organizational machine is a source of dismay. One is haunted by the suggestion that the very purpose for which our Service was established gets put on the back burner. Too many important things fall between the cracks and no one is quite sure why. Our little experiment was conceived out of our anxiety that attention to the visitor, his experience and needs, was less than complete. While there are multiple examples of excellence, there also are glaring voids.

We needed a common sense evaluation of our collective response to Yellowstone's visitors – direct and immediate feedback to managers and supervisors that can be translated into constructive and responsive change. We do not need a weighty study cast in statistical jargon geared to meet astringent academic criteria.

What to do? Everyone is busy, overloaded, and will never have time for introspection and assessment. Besides, we all have territory to protect and don't appreciate our peers and colleagues being critical of our programs. Enter Jean Merriman; perceptive, critical (yet not threatening), positive, empathetic, and a person whose understanding of organizational psychology and other "realities" allowed her to be a catalyst – the ideal Visitor Advocate. Following is her description of our experiment.

Bob Barbee, Supt.
Yellowstone National Park

Yellowstone's Superintendent, Bob Barbee, introduced an innovative management scheme in the summer of 1985 with an experimental seasonal position having three broad guidelines: Improving the visitor's experience and, if possible, making it better quickly if it were not what it should be; looking into why things fall through the cracks; and making the administration more responsive. This unusual concept was put to the test when the nod went to me for the position. As a Professor of Environmental Studies and Planning at Sonoma State University in California, I had taught for many years in an interdisciplinary field and was in some sense pre-adapted to think wholistically and synthetically in terms of where the complex parts fit together to make the Yellowstone operation tick. While having no long-term career stake in any aspect of the park's bureaucracy, I had 12 years' seasonal experience at Yellowstone and Acadia National Parks, which gave me the insider's view of how things are done.

In a sense, I created my own structure as the position evolved. At the outset it seemed that some level of accountability was in order, so I kept a daily log of my activities, which I discussed with the Superintendent about once a week. A couple of typical entries:

> 6/22 Checked out visitor complaint about toilets at Fountain Paint Pots. Whew!
>
> 7/27 Wide ranging discussion with Canyon Maintenance Foreman re amphitheater repairs and winter operation, especially re warming hut and needs for sewage and water.

These notes were always somewhat cryptic. My goal was to fact-find in order to improve situations, not to fault-find. I needed to get candid input without posing a threat to people and careers. I tried several approaches to finding out what Yellowstone visitors were really experiencing; looking at visitor complaints, reading reports of problems from field staff, interviewing as many employees as possible from the Safety Officer to waiters, top management to seasonal personnel. At times I posed as a typical park visitor – I called her Sara Jones from Illinois – eating the food, camping, attending activities, and sleeping in concessioner lodging. On one occasion I was accompanied by my wheelchair-bound mother which permitted an experiential evaluation of handicapped access.

Having gathered information in this way, I selected some of the material for presentation at the weekly Squad meetings. These presentations followed such themes as, "What are we doing that is inconvenient or confusing for visitors?" For instance, for eight seasons there were visitor and staff complaints about errors in the park map but the solution somehow had kept eluding us. This was solved easily with a quick check on the accuracy of the proposed 1986 map. A more complex issue was how to improve and simplify the complicated system used to obtain permits and passes. While no one liked the status quo very much, there were constraints inhibiting change: money, staff, physical plant and the habit of always having done it that way. The upshot of these discussions was to set a 1986 management goal for reviewing the whole process of issuing boating, fishing and backcountry permits and the Golden Age/Golden Access passes.

Another of my presentation themes was, "What do the visitors find after we invite them to a particular place in the Park?" In this instance, I brought the park to the Squad meeting via two slide presentations. The first focused on the physical degradation of Natural Bridge, a delightful little area on a side road, which was losing the priority battle to better known attractions such as Old Faithful. As a result of the presentation, the area has been scrutinized by top management, with the likelihood that eventually there will emerge specific plans for the area. The second slide presentation dealt with the amphitheaters which, in 1984, were attended by 170,000 visitors. Signing, siting, and maintenance ranged from adequate to poor in 10 facilities. The goal here was to highlight the need for an interdisciplinary team, including naturalists, the safety officer, planners, handicapped access specialists, and maintenance personnel, to create for the amphitheaters a maintenance schedule that was on a fast track in line but with budgetary and use realities. In both instances, field people and administrators across all divisional lines were made aware that a natural place and several much-used facilities were in need of attention and that improvement would dramatically enhance the visitor's impression of Yellowstone.

The literature that the Yellowstone visitor gets, whether free or purchased, is highly varied in style and quality. Each piece evolved from some need of the moment or some opportunity to tap a particular expertise. The output is often redundant and frequently laced with inconsistencies and errors, which is not surprising, since publications involve at least six different, relatively independent offices. While I was certainly not the first to see the need to develop an organizational process for overview of printed materials, I was able to be a catalyst for change. I began with a short paper for the Superintendent pointing to the poor economy and matching result of run-away publications. He responded by drawing together representatives from various pertinent divisions and offices to address the problem. My role was that of a facilitator with this group, directing and organizing the initial meetings until a chair could be selected. The work of the committee is on-going, but seems to be moving toward developing a logo, style and content standards, and recommendations for restructuring the publication process.

Visitors expect every uniformed NPS employee to be able to answer their special questions. It's not possible, of course, but it was clear that there was room for improvement in Yellowstone, and that the situation might be addressed by a training and orientation program. I found that nearly half of the high-public contact employees received no special preparation for this range of questions, especially maintenance and some concessioner people, and that others such as the naturalists and rangers had different and highly specialized programs. Superintendent Barbee again gave me a facilitator's role to get a broadly representative group together to address these issues. This group's work, too, is on-going, with the goal of giving Yellowstone's employees a baseline orientation program with information about the mission of the park, an understanding of specific job roles and a competent grasp of the mundane but critical information that visitors need.

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Information Crossfile

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article by Steven Golden of the U.S. NPS, titled "Our Ways and Your Ways," comparing and contrasting the British and U.S. park systems. The newsletter's editor is Ann Ewins, John Dower House, Crescent Place, Cheltenham, Glos., England GL50 3RA.

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A small, harmless weed, *Arabidopsis thaliana*, may prove as helpful in the field of plant genetics as the fruit fly *Drosophila* has to animal geneticists and the bacterium *E. coli* has to microbial geneticists. Initial work on this tiny plant of the mustard family is described in the Sept. 20, 1985 *Science* by Elliot M. Meyerowitz and Robert E. Pruitt of Caltech in Pasadena. The complexity of plant genetic material (the genome) has been a barrier to progress in understanding the mechanisms of inheritance and in applying that knowledge to genetic engineering. *Arabidopsis* contains only about 1 percent the amount of DNA in wheat, and less than 0.5 percent the amount of repetitive sequence. Its life cycle is five weeks and one plant can produce thousands of seeds.

Visitor Advocate

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A third major guideline for my work was to help the administration be more responsive to all sectors of this 2½ million acre park. No one story is remarkable, but many small instances added up – informal notes to the assistant superintendent, the landscape architect, the concessions specialist and others, made the right connection about things as varied and commonplace as toilet installations, road stripes, weather reports and phone procedures. I actively sought ways to recognize people outside the administration by suggesting that certain commendable staff achievements might be interesting COURIER stories.

The superintendent's unswerving support, often stated publicly, was particularly important to me personally, for I felt the void of not having co-workers with whom I could check things out. The combination of Barbee's public support and the novelty of the approach had intangible payoffs – some of the ideas set in motion may surface later in beneficial ways. We found that just asking the right question in the right context could set repairs and remedial actions in motion.

Dr. Gary Machlis, Project Leader of the NPS Cooperative Park Studies Unit at the University of Idaho, has written about the conditions that make change possible. Paradoxically, we all need change and yet we all resist it. After all, even "going from bad to worse" is a change. One criterion for acceptance of a novel idea or procedure is that it be explicitly defined as an experiment so that if it is inappropriate it won't be set in concrete. My work was clearly labeled an experiment for a summer and as some good results began to emerge the skeptics became supportive and helpful in ways that reinforced what I was doing.

Dr. Machlis has lectured on employee burn-out in NPS settings. According to him one positive step in alleviating this dread phenomenon is providing employees an opportunity to be heard by someone. I am touched, really, that people entrusted so much in candor. I responded with scrupulous discretion, or as the aphorism goes, "We were designed with two ears, always open, and one mouth; it will close."

The question remains: "Is this unusual management approach unique to the personalities of those involved? In certain particulars, possibly yes. But I feel that on overview of the entire operation, made by an outsider with sensitivity to the inner social order of parks, for the purpose of giving the superintendent information he needs to know, has a place.

Perhaps a suitable job description, provisionally titled, "Visitor Advocate" might be:

> Incumbent must have several seasons prior NPS experience, VIP-retirees desirable; no career stake beyond professionalism; positive view of people; communication skills; tolerance for travel and social isolation; high tolerance for ambiguity.
>
> Rewards – flexible schedule, highly varied work, the chance to meet a lot of the park family you'd never meet otherwise; unlimited opportunity for creativity and a view of the big picture that expands one's sense of the National Park mission.

Merriman is Associate Professor in the School of Environmental Studies and Planning, Sonoma State University, Rohnert Park, CA 94928.

Electrolysis Proves Useful In Preserving Metal Relics

By Herbert C. Bump and Frank H. Gilson

The Florida Research and Conservation Laboratory, begun in 1967, is a section of the Florida Department of State's Bureau of Archaeological Research. The lab was set up originally to conserve and stabilize artifacts relating specifically to the history and prehistory of Florida and to serve the conservation needs of the various museums and historical societies in the state.

However, in recent years the lab has expanded its operations and now contracts to do conservation work for the National Park Service, historical societies, organizations and state government agencies throughout the United States, and the Caribbean. The volume of artifactual material processed annually through the lab has tripled in the past two years. Even so, the amount of conservation work still needed is staggering, and many objects of cultural, historical or archaeological importance are being lost each year.

Much of Florida's history lies beneath the sea in the form of shipwrecks. Although is also treats artifacts, the Florida Research and Conservation Lab specializes in the preservation of coastal and submerged artifacts, which pose a special problem. The corrosion processes of iron in aquatic or coastal environments are generally known but the reactions are complex and subject to many interacting variables. It is usually possible, however, to determine what conservation alternatives are warranted for any artifact through visual inspection and knowledge of its previous environment.

On old shipwreck material and items from coastal environments the most prevalent iron corrosion products are ferrous sulfide, magnetite, ferrous hydroxide and iron chloride. Once iron has been contaminated by exposure to a submerged or coastal environment the corrosion process will continue, and even accelerate. If the iron artifact is exposed to the air, the ferrous compounds can oxidize to a ferric state where they occupy a greater volume and scale off the surface. This process can disfigure a piece and eventually destroy it.

The greatest damage, however is caused by iron chlorides. Iron, especially cast iron, is highly porous. Sea water penetrates the artifact and carries corrosive chlorides (salts) deep within the metal. If the artifact is later exposed to the air, the water will evaporate, leaving the salts behind. Allowing a metal artifact to dry without removing the salts will cause damage and eventual destruction of the artifact.

Many artifacts throughout the United States have suffered from continuing corrosion through the years and will eventually be worthless unless conservation measures are taken, but most are still worth the effort required for preservation. Detecting corrosion problems before they get out of hand is a relatively simple procedure. One may begin by looking at the artifact for the following visible conditions:

1. Is the iron leaking a bluish-purple stain on its surface or on its coating? *(Photo 1)*
2. On a hot dry day does the iron show small beads of liquid on its surface? *(Photo 2)*
3. Is the iron cracked? Cracks will usually appear along sharp edges first. *(Photo 3)*

The photos illustrate dramatic conditions. If any of the conditions can be seen with the unaided eye, the artifact should be considered for treatment. The badly damaged cannon in *Photo 4* illustrates what will occur if nothing is done.

Electrolysis is the commonest method of extracting corrosive salts from ferrous and other metal artifacts. This oxidation-reduction process uses an artifact as a cathode, an anode, an electrolytic medium and a DC power source. The process involves negatively charging the salt ions inside the metal so that they are attracted toward the positively charged anode and

Photo 1

Photo 2

thereby extracted from the metal.

Commonly, the artifact and anode are submerged in a tank of liquid electrolyte. However, the industrial sector has long used a "dry" electrolytic technique to protect reinforcement rods in poured concrete structures – an instance where submersion in electrolyte is not possible. In this technique, a conductive mastic, which serves as the anode, is painted directly onto the concrete. The reinforcement rod becomes the cathode while the natural dampness in the concrete acts as the electrolyte. This particular technique is especially useful in the preservation of historic reinforced concrete structures located along Florida's coastline.

Another electrolytic technique used by the research and Conservation Laboratory is underwater cathodic protection. This technique is used to protect submerged iron artifacts such as cannons or metal hull ships. Using the same principle as that used to protect outboard motors or offshore drilling rigs from salt corrosion, zinc "sacrificial" anodes are attached to the iron artifacts. In this case the seawater itself acts as the electrolyte.

Underwater cathodic protection is used to preserve historic iron shipwrecks that may be salvaged entire at some future date. It may be used in the preservation of submerged displays such as the reproduction of an 18th century shipwreck at Pennekamp Coral Reef State Park at Key Largo, Florida. It may also be used for the preservation of submerged national shrines that are to remain *in situ* but are beginning to show signs of deterioration.

Electrolysis is an effective preservation tool; however, no amount of technique can overcome lack of interest in the field. Even after artifacts needing preservation are identified, preserved and stabilized, some care must be taken in performing preventive maintenance. It is most disheartening to the conservator visiting a historic site to find the valuable artifact that he so carefully preserved six months before, deteriorating through lack of simple maintenance.

Bump is Conservation Lab Supervisor and Gilson is Lab Technician/Archaeological Illustrator for the Florida Research and Conservation Lab in Tallahassee.

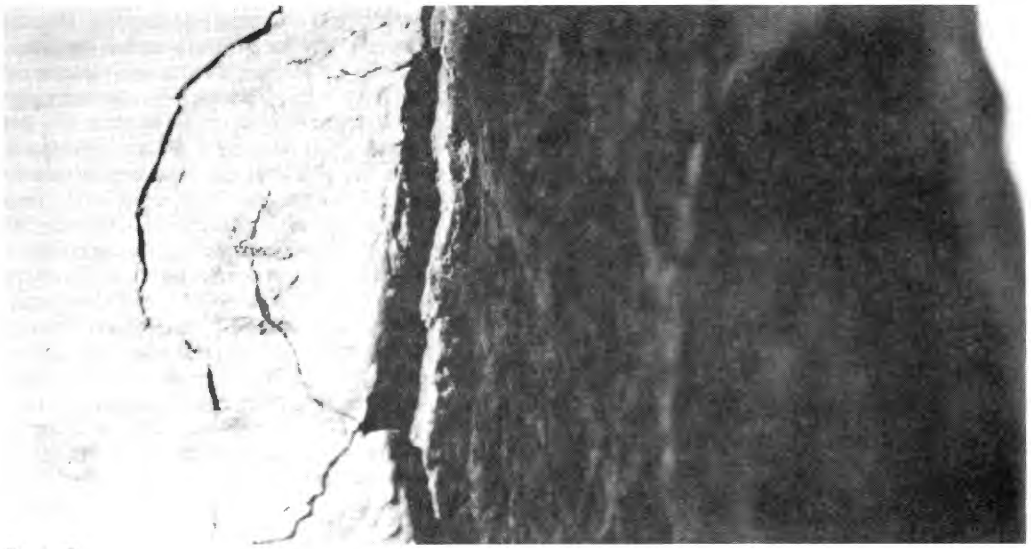


Photo 3

Photo 4

From Trace Elements To Prehistoric Diets

By Judith Miles

Archaeologists are constantly adapting to their own uses the advancements made in other fields of research. Currently, we are witnessing the development of a technique to assay chemical content in various substances for purposes of interpreting the diet and the environment of prehistoric people. Generally, this is done by identifying components of the food chain and evaluating the amounts of trace minerals and carbon isotopes that are transmitted through the system. A chemical bone analysis technique is applicable now to many archaeological study areas, and it promises to become more versatile as refinements are made.

The Method

Through the use of highly sophisticated equipment, relative proportions of certain minerals (e.g. strontium, zinc, magnesium, calcium, sodium, copper) and carbon isotopes can be measured to yield information characterizing prehistoric diets. Bone and its components, teeth, and flesh are the principal materials assayed; normal trace element quantities differ relative to the tissue type being assayed.

Analysis requires a 0.5 gram sample – sometimes less. The measurements cannot be interpreted directly as distinct diets. Instead, interpretation is made from patterns and relative ratios, distinguished in each level of a particular food chain. To do this, analysis must extend to soil, plants (both wild and cultivated), herbivores, and carnivores, as well as human remains. Most importantly, all these must be derived from a single spatial and temporal subsistence base.

Experiments using atomic absorption spectroscopy and electron microprobing reveal which minerals are the most stable (resistant to leaching) under various conditions and thus are most reliable to measure. Carbon isotope analysis, using any of several techniques, can define different carbon isotopes remnant of agricultural, hunting, gathering, and mixed subsistence strategies.

Application of Carbon Isotope Analysis

The application of carbon isotope analysis can be illustrated in the following manner.

Maize and other plants whose genetic pools have adapted to strong sunlight follow a photosynthetic process called a C_4 pathway; it uses a higher frequency light wavelength than do trees, wheat, and other plant foods that have adapted to a more mesic (moderately moist) climate. The photosynthetic process used by these plants is called a C_3 pathway. C_3 plants are more discriminant against carbon 13 (^{13}C), a fact that results in a more negative ratio of carbon 13 isotopes to carbon 12 isotopes (^{13}C to ^{12}C) in bone collagen of animals that eat C_3 plants as compared to that produced by eating C_4 pathway plants.

(An isotope is one of two or more species of atoms of the same chemical element that have the same atomic number and occupy the same position in the periodic table and that are nearly identical in chemical behavior but differ in atomic mass or mass number and so behave differently in the mass spectrograph . . .

Continued on next page

Trace Elements

Continued from previous page

and may be detected and separated by means of these differences. The "superscripting" (as in ^{13}C) refers to the atomic number of an element; the "subscripting (in this case, C_3) indicates the number of carbons involved in photosynthesis.

Patterns of the ^{13}C to ^{12}C ratio, derived from skeletal remains, serve to distinguish the relative amounts of C_4 pathway foods (such as maize), C_3 pathway foods (such as wheat), and diets that have consisted of mixed grains. The earliest North American cultures for example did not have maize. The historic movement of maize as it gradually was domesticated and moved northward from Mexico into areas deficient on other C_4 plant foods, can be read in the changing ^{13}C to ^{12}C ratio that occurred in human bones and therefore in the subsistence base.

The earlier C_3 diets show a range difference in the carbon isotope ratio than later maize-based diets. Arti factual and botanical evidence of intensified agricultural activities seems to confirm the implications of the carbon isotope analysis.

Applications of Trace Mineral Analysis

Mineral content also provides clues to the food system being exploited. The idea is based on the premise that individuals subsisting on similar diets will show the same relative proportions of different minerals. Trace element analysis of strontium (Sr), for instance, is largely determined by the amount of meat consumption. In accord with the latest scientific information, high levels of Sr suggest a preference for a more *vegetarian* diet, with lower intake of meat. Even when C_4 plants are introduced into the diet, dependency on meat might still be tracked. (Interpretation must take into account the diet of the animals that were consumed.)

An important recent development in trace element analysis is the strotium-to-calcium ratios (Sr/Ca). Generally, Sr/Ca decreases progressively as it moves up the food chain because Sr is discriminated *against* and Ca is discriminated *for*, progressively, in normal mammalian metabolic processes. If Sr/Ca references can be developed for each level in the food chain, then human remains of those who exploited that food chain can be compared for similarities in Sr/Ca ratios. In so doing, we are closer to knowing who ate what and where along the food chain. Prehistoric human burials, the matrix in which they are buried, and samples of the available food base are the raw materials for mineral trace analysis.

Theoretically, the information this kind of analysis yields would give archaeologists evidence to identify people who had "preferential access" to high-protein food sources or to describe a community where food resources were utilized equally but acquired through task specialization. The former suggests an elite element in the social structure; the latter implies an exchange mechanism in the economic system.

Problems to Reckon With

The samples analyzed for trace elements present problems which will come under increasing control as improvements are made in the technique. The amount of environmental contamination in bones must be discerned. Sr/Ca uptake by plants varies according to the available Sr and Ca in the soil, water, and air. Studies show that the highest Sr concentrations in the U.S. currently are in the Southwest. Therefore, care must be taken to obtain samples that were associated and to ascertain the degree of alteration the samples have encountered since their deposition.

A further complication is that several variables can affect Sr/Ca in bone. Biological development stages affect a person's metabolic rate which, in turn, produces very high variations of Sr/Ca in growing individuals. The most variability seems to occur between 4 and 13 years of age. On the other hand, infants with similar metabolic rates may have entirely different ratios. The controlling factor is whether or not they are weaned, since mammary glands effectively discriminate against Sr in a mother's milk. Other factors include Ca levels in the diet, which affect the amount of Sr absorbed. Thus, the vital statistics and nutritional profile of the individuals comprising the population are important to properly interpret analytic results.

Most of the other technical problems facing researchers in this area have been fairly well defined and therefore can be effectively dealt with. Not the least of these is the use of a destructive analytic process that requires some tough calls – whether the information to be gained is worth the consumption of the material.

Recommendations for Future Research

Carbon isotope analysis found its way into the scientific community several decades ago and thus has fewer problems in application than does the new trace element analysis of mineral in bone. Given the results of current research, the most important known factors that modify normal Sr/Ca levels are diet, age, health, and sex of an individual, plus any postdepositional effects on the skeleton. Care must be taken to assess the effect of these variables has on the data.

This type of chemical bone analysis can be applied to many different cultural settings and topics of research, such as detection of increased dependence on dairy foods, determination of the estimated age of weaning, explanation of the effects of diet on craniofacial morphology, identification of dietary adaptations to differing environments, pinpointing differential access to protein sources within a geographic area.

A major benefit of trace element analysis is that it can provide insight into the diets of healthy individuals rather than only the nutritionally stressed population as perceived through the more common approaches in paleopathology.

The kind of socio/environmental insights provided by such carefully researched information can add immeasurably to the interpretation of our ancient cultural resources.

Miles is an Archaeologist with the Division of Cultural Research, NPS, Southwest Regional Office on the University of New Mexico campus. (P.O. Box 2617, Albuquerque, NM 87125).

Fort Vancouver Builds Its Own

A phone call to *Park Science* from Fort Vancouver NHS started this story. Jim Thomson, the Fort's superintendent, was reporting on an electroysis technique for preserving and reclaiming the metal artifacts then being uncovered at the site. He also credited the method with slowing the march of time and oxygen toward eventual demise of the long-stored metal treasures that had previously been unearthed there.

For nearly 40 years, the trove of significant relics had been building up at the old fort site. Excavations that were begun in 1946, had resulted in the 1948 establishment of Fort Vancouver as a unit of the National Park System. Then, in 1976, with construction beginning for a new highway complex that would cover the old Fort village site, excavation work was accelerated. As the "digs" went down, the cache of artifacts went up.

Bryn Thomas, working out of the archaeological department at Eastern Washington University and under the auspices of the Washington State Department of Transportation, supervised the village excavations. A contract between NPS and Eastern Washington U gave Thomas the job of cataloging the artifacts, after which they wound up in cardboard boxes in the back of the reconstructed Indian Trading store.

Examination showed marked deterioration of the metal. Treatment was necessary if the relics were not to become mere piles of red dust. Instead of sending the collection to Eastern Washington U for treatment, Pacific Northwest Region Curator Kent Busch suggested treating them at the Fort.

Enter Herb Bump from Florida.

The June 1985 phone call from Thomson resulted in the picture story on the Fort Vancouver operation. A phone call from *Park Science* to Bump elicited the companion piece by Bump and Frank H. Gilson, describing the process and the work being done at the Florida Research and Conservation Lab in Tallahassee – part of the Bureau of Archaeological Research in the State Department of Archives, History, and Records Management.

A pair of scissors, *recovered from one of the recent village excavations, is lifted from the processing tank to show the corrosion which is being arrested by immersion in the sodium hydroxide solution and subjection to the weak current. Several months may be required to rid the metal of its corrosive elements and arrest deterioration.*

Through Darkest New Mexico With Tongue in Cheek — Or The Exotic African Oryx

By Milford Fletcher
Southwest Region Chief Scientist

What the Devil is an Oryx?

This question has been heard frequently in New Mexico during the past few months as the National Park Service surfaced plans to remove the beasts from White Sands National Monument.

The animal in question is the African Oryx, or Gemsbok *(Oryx gazella)*, which was introduced into New Mexico in the late 1960s, along with three other exotic animals from the Old World.

The purpose of these introductions is still debatable. Ostensibly, the reasoning had to do with providing huntable populations. Behind this stated purpose was a rationale best described in the book *Pleistocene Extinctions*, by Dr. Paul Martin, which argues that a substantial number of large ungulates became extinct about 10,000 years ago – a situation that Dr. Martin argues was brought about by primitive humans, who found a "naive prey" when they crossed the Bering Straits and swept through North America on their way to fame and fortune in New Mexico and Central America. Dr. Martin and his adherents insist that with the demise of these numerous, large ungulates, an ecological "vacancy" has existed in the southwest for centuries, and the introduction of these species was meant to fill that gap!

Be that as it may, in the late 1960s and early 1970s, the New Mexico Dept. of Game and Fish began an introduction program to provide huntable populations of several nonnative animals. These include the Barbary sheep, two species of Ibex, and the Oryx. There were 93 oryx released between 1969 and 1973; the population in the Tularosa Basin now is around 800 animals. They were released north of White Sands National Monument on land managed by the U.S. Army White Sands Missile Range and Holloman Air Force Base, east of the Monument.

Through the years, the oryx have extended their range south (and all other points of the compass), until they began to be noticed on the Monument in increasing numbers. They were identified as a problem as early as 1973 in the Resource Management Plan for White Sands. A modest research project led to the conclusion that there were between 50 and 100 oryx on the west and southern portions of the Monument and their range was spreading.

Since NPS policy is clear in regard to exotics, steps were taken to include the oryx in the NPS Natural Resource Preservation Program projects. The proposal included funding to fence the southern and western boundaries of the Monument. Over two years, more than $400,000 of fencing was built along about 19 miles. The fence, an 11-strand smooth wire creation, was designed by the SW Regional staff for the specific purpose of excluding oryx. These largest of the African antelope have weights at maturity of up to 440 pounds and horn lengths of well over 50 inches.

On May 25, 1985, NPS staff and observers from the New Mexico Dept. of Game and Fish and the White Sands Missile Range met to conduct census and removal of the oryx. In 6.4 hours of helicopter time, 18 animals were driven from the park. The fence had been completed on the southern end of the Monument some two weeks previously, and aerial observations showed a herd of 48 animals which had fortuitously been out of the Monument when the fence was completed.

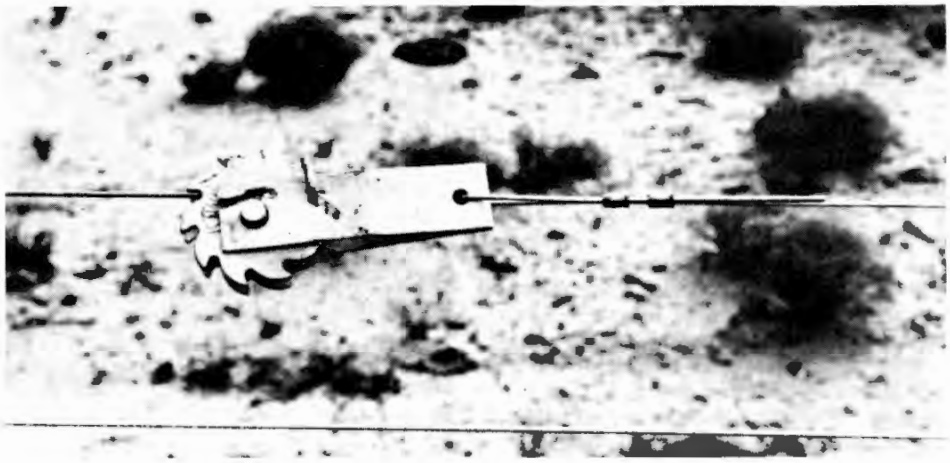
Approximately 30 percent of the animals removed were juveniles, which indicated a rapidly growing population. Management is difficult because three sides of the Monument are managed by the U.S. Army and our neighbor on the fourth side is Holloman AF Base. Aerial activities must be coordinated well in advance and limited to a few hours each day because of the missile-testing and "star wars" weapons development on adjacent lands.

The north side of the Monument remains unfenced, and how far these animals will move to circumvent the fence is uncertain. The existing fence, however, appears to be successful in preventing ingress. The fence was built with treated wood posts driven at either 16 or 20 feet intervals. Metal posts rapidly deteriorate in the calcium sulfate soils of the Monument. Wire strand numbers can be adjusted vertically to meet the particular need. [We, for example, put the first wire 18" above ground to allow American antelope *(Antilocapra americana)* to pass under the fence.] The strands are then stretched to 250 lb./sq. inch. This allows the wires to stretch against a spring but they will not break when hit or pushed on.

The author has, himself, hit the fence at a dead run and been bounced back as though from a trampoline. Other wildlife have shown the same reaction. We feel this type of fence may have applicability in other NPS areas. The cost ($3.50 per linear foot) is comparable with other high-quality fencing. Details can be obtained from the Division of Natural Resource Management, PO Box 728, Santa Fe, NM 87501.

The oryx problem at White Sands National Monument is not solved. Continued aerial drives will be conducted and both the military and New Mexico Department of Game and Fish will be urged to help deal with the serious exotic ungulate problem on the Monument.

The fence (above) and the fence-tightener (below), specifically designed to help solve the African oryx problem at White Sands National Monument. The tightener stretches wire to 250 pounds per square inch.



Cultural Landscape Management at Buffalo National River

By Ric Alesch

Editor's Note: *Boxley Valley in the Buffalo National River is the setting for a "high level meeting" of natural science and cultural history, and the blending of National Park Service objectives with community pride and wishes.*

Ric Alesch, an NPS Denver Service Center park planner, sees the Boxley Valley process as a long-term experiment in the creative formulation of the most difficult kind of management plan that faces the Service: "the issue of how to perpetuate the private, agricultural community in harmony with the historic scene, natural resources, and appropriate visitor use."

The pressing problem, according to Alesch, is the disposition of vacant farm buildings that are falling into disrepair. But other sticky issues include the desirability of allowing new houses, grazing, and appropriate commercial activities. Resource management issues include the valley's historic significance, forest encroachment on vacant farmlands, streambank erosion, and water quality. Visitor use and development issues include how to enhance the drive-through experience and where to develop trails in the valley. One of the most difficult questions, Alesch said, is what "management agreements" should be used to implement any plan. (He mentioned leasing vs. sellback as an example.)

This is a story that goes beyond the usual focus of Park Science, *but because it involves the fruits of scientific research and deals heavily with natural resource management, and because these matter are here considered within the larger framework that so often tends to modify the "pure findings," it was decided to let Alesch tell the story from the point of view of the project manager. It holds lessons for everyone involved in both input and outreach, and it speaks directly to some mandates laid down recently by Director Mott.*

The 1975 Master Plan for Buffalo National River (BUFF) designated the Boxley Valley is a "private use" zone, "including some farmlands that may continue in private ownership, subject to scenic controls and necessary rights-of-way for roads and trails as long as water and air pollution are not increased." The master plan does not provide any details on management of the valley, and for various reasons the NPS has acquired fee-simple ownership of most of the valley although many sellers retained "use and occupancy" agreements for up to 25 years.

In 1983, the park and Southwest Regional Office (SWRO) staff identified the need to develop a management strategy for Boxley Valley. The Denver Service Center (DSC) was requested to study Boxley and prepare a management plan. The overall issue is how to perpetuate the private, agricultural community in harmony with the historic scene, natural resources, and appropriate visitor use.

A planning team was organized consisting of myself as project manager, Mike Bureman, cultural resource specialist, DSC; Steve Chaney, resource management specialist trainee, BUFF; Doug Faris, chief of planning and design, SWRO; Craig Frazier, historical architect, DSC; Alec Gould, BUFF superintendent; Jim Liles, BUFF asst. supt.; John Murphy, landscape architect, DSC; and Laura Soulliere Harrison, architectural historian, SWRO.

A task directive was prepared to identify the product, clarify the issues, identify data needs, develop a schedule, specify public involvement strategies, and clarify responsibilities. Because this project was an unusual planning effort and the first attempt at a cultural landscape report, this was a critical and relatively time-consuming phase.

The next step was to assemble resource data for the area. A historic resource survey was conducted by the cultural resource specialists on the team. This involved several weeks of fieldwork to evaluate the area, which includes over 200 structures. They categorized structures into four levels of significance, and determined that the valley should be nominated to the National Register of Historic Places as a cultural landscape (rural historic district). This effort drew upon a recently completed oral history project for Boxley Valley. Nomination forms have been prepared by DSC, and SWRO will be submitting them to the National Register office in Washington soon.

Other resource information that was developed or assembled includes slopes, characteristic viewpoints, open field visibility, vegetation, geology, floodplains, soils, endangered species and archaeological sites. Data were analyzed on existing landownership, land use, visitor use and development. A series of overlay maps were produced for these data using a common topographic base map.

Then came the hardest part – using this information to develop a management plan for the valley. Through a series of team workshops, we developed a set of alternatives addressing the issues identified in the task directive. We also brought in several "consultants" for a day or two to work on certain problems. Among these experts was Joe Sax, Professor of Law from the University of Michigan. He provided input on concepts and techniques for preserving communities in national park areas. Bob Flanders of the Center for Ozark Studies at Southwest Missouri State University also provided valuable insights. Another source of information and inspiration was Robert Melnick's earlier work at Boxley and the draft NPS manual on cultural landscapes he was developing at the time.

After much discussion, debate, and several review drafts, DSC printed the *Draft Land Use Plan/Cultural Landscape Report/Environmental Assessment* in September 1984. Four alternatives were presented for guiding management of Boxley Valley. Alternative A, the "no action" concept, would have continued the trend of emphasizing natural resource preservation. Alternative C stressed traditional historic preservation and Alternative D stressed private use. The preferred alternative, B, attempted to balance these objectives while managing change in the valley.

The final plan, completed and approved in April 1985, is now in print and available through the park

Pastor's parsonage *(left), the Boxley church (center), and the former Boxley school, now used as a community building, are among the visual rewards of practicing "open field visibility" at Buffalo National River.*

and the SWRO in Albuquerque, NM. It proposes a long-time cooperative effort with the Boxley Community, including private efforts to maintain existing houses with some new homes allowed. Haying, grazing, orchards and crops will be permitted with good conservation practices employed. The reestablishment of a community store is proposed and "bed and breakfast" operations are encouraged.

Historic structures will be preserved through traditional use; modifications and new construction will be subject to guidelines included in the plan. Most fields will be kept open through the agricultural uses described above. A forested buffer zone will be maintained along the river to preserve riverbanks and protect water quality. Measures will be taken to eliminate or reduce livestock access to the river. Information waysides, scenic pullouts and trails will be developed to privde for compatible visitor use.

The Park Service will develop "management agreements" with individuals to encourage continued private use and cultural resource preservation, including land exchanges, resales, and lease agreements under the National Historic Preservation Act. Funding for implementation will come primarily from private sources, along with some NPS operating funds and lease revenue.

One of the keys to the Boxley Valley plan's success is that it is a comprehensive document prepared by a multi-disciplinary team including DSC, park and regional office personnel. The critical cultural, natural, and visitor use issues were dealt with concurrently and solutions negotiated to make it work. Some of the issues continue to be controversial and the plan is not without imperfections; but, most people within and outside the Park Service have claimed it is a good document.

A major key to the study's success is the public involvement effort. The team had informal meetings with valley residents at the issue identification and alternatives evaluation stage. A public meeting was also held on the draft plan. Various members of the team spent considerable time talking to residents individually. Other members of the park staff also have been working on improving the once-sour relationship between NPS and the Boxley community. In addition, the team worked with staff from the state historic preservtion office and Advisory Council on Historic Preservation during the course of the project.

Much remains to be done over the next five to ten years. This includes negotiations with existing landowners, appraisals, deed documents, farm management plans, archaeological surveys, lease agreements, and monitoring. A good direction has been established; a lot of follow-up work will be needed in the years ahead.

The Boxley study has shown that through a comprehensive effort, with appropriate data, the right team, extensive public involvement and a commitment by management to follow through, a major cultural landscape can be preserved for the benefit and enjoyment of future generations. DSC is currently beginning a smaller scale effort to develop a similar plan for a more modest cultural landscape in the Erbie area at Buffalo National River.

Alesch is a Park Planner at the NPS Denver Service Center.

***Two haying machines** on adjacent farms within the boundaries of Buffalo National River continue to operate under the Boxley Valley plan.*

meetings of interest

1986

March 3-6, PRESCRIBED BURNING IN THE MIDWEST: STATE OF THE ART, at Stevens Point, WI. Contact, Andi Koonce, Coll. of Nat. Res., U/WI, Stevens Point, WI 54481, or (715) 346-2269.

March 21-26, 51st NORTH AMERICAN WILDLIFE AND NATURAL RESOURCES CONFERENCE, MGM Grand, Reno, NV.

May 1-3, INDIANA DUNES RESEARCH CONFERENCE, Indiana University-Northwest, Gary, IN. Contact Ron Hiebert, Indiana Dunes National Lakeshore, 1100 N. Mineral Springs Road, Porter, IN 46304.

May 12-16, FIRST NATIONAL SYMPOSIUM ON SOCIAL SCIENCE IN RESOURCE MANAGEMENT, Oregon State University, Corvallis. Contact, Donald R. Field, NPS/CPSU, OSU 97331.

June 22-26, TENTH BIENNIAL NORTH AMERICAN PRAIRIE CONFERENCE, at Texas Women's University, Denton, TX. Contact Native Prairie Assn. of Texas, Texas Women's U., P.O. Box 22675, Denton, TX 76204.

July 13-20, CONFERENCE ON RESEARCH IN THE NATIONAL PARKS, NPS and George Wright Society co-sponsors. At Col. State University, Fort Collins. Contact, Ray Herrmann or Calvin Cummings, 339 Aylesworth Hall NW, Col. State U., Fort Collins, CO 80523.

Oct. 25-28, CALIFORNIA CHANNEL ISLANDS SYMPOSIUM, Santa Barbara, CA. Contact, Gary E. Davis, Channel Islands NP, 1901 Spinnaker Dr., Ventura CA 93003.

1987

Sept. 12-19, THE FOURTH WORLD WILDERNESS CONGRESS. Denver, Estes Park, and Fort Collins, CO. Contact Dr. Jay Hughes, Chairman, Dean of Coll. of For & Natural Resources, Col. State U, Fort Collins, CO 80523.

*See also **Meetings of Interest** in previous issues of **Park Science.***

Help!

Jeff Marion, Mid-Atlantic Region Research Biologist, is conducting research on campsite and trail inventory/impact assessment and monitoring systems. He also is interested in investigating the application of field data recorders, microcomputers and software for increasing the efficiency of implementing these systems. People who have developed or worked with these kinds of systems are asked to contact Jeff by phone or mail: Star Route Box 38, Milford, PA 18337 (717-296-9280).

Landscape of the Past:
Prairie Management at Herbert Hoover National Historic Site

By Steve Robinson

Over a quarter of a million people each year are drawn to West Branch, Iowa, the birthplace of the first president born west of the Mississippi. Here, visitors to the Herbert Hoover National Historic Site can walk through the two-room cottage where the president was born and lived his first five years. They can visit the Herbert Hoover Presidential Library-Museum, the Quaker Meetinghouse where the family worshipped, the first one-room schoolhouse built in West Branch, and, during the summer, can watch a blacksmith at work in the Jesse Hoover Blacksmith Shop.

But there are other resources of a different nature within the park that also played an important role in Hoover's early years in Iowa. The park includes a 76-acre tract of reestablished native Iowa prairie – one of the largest areas of reestablished prairie in the state. Hoover recalled his boyhood in the 1870s, playing in small areas of virgin prairie along the Wapsinonoc Creek and the Burlington track – remnants of the days when more than 85 percent of Iowa was prairie. He spent the summer of 1882 in Sioux County, Iowa with an uncle who was breaking in a prairie farm, and one of his most vivid boyhood recollections was riding the lead horse of the team that pulled the plow through that virgin prairie sod.

The Hoover Prairie *stretches away like a golden ocean around the Isaac Miles farm at Herbert Hoover NHS.*

The goal of NPS at Hoover NHS is to restore the Hoover prairie to its appearance of 200 years ago, before European settlers arrived in the area. Until 1971, the area had been under cultivation. In accordance with the park's master plan, the 76-acre tract was seeded with five different species of native prairie grass – big bluestem, little bluestem, sideoats gramma, switchgrass and Indian grass. A variety of prairie forbs were introduced later in some parts of the prairie. The grasses soon became very well established, so much so that they crowded out most of the forbs. Over the years, however, one vital element of the prairie's ecology was omitted – fire. Even though a well-established stand of grasses was present, there was nothing to prevent the gradual encroachment of woody species and noxious weeds.

The seeding effort in 1971 was the beginning of a long series of management techniques that have been employed over the past 14 years. By 1976, those areas of the prairie with the heaviest concentrations of weeds were mowed each fall, and crews of Youth Conservation Corps (YCC) workers would hand-clip individual thistle plants throughout the rest of the prairie. This was done in an effort to eliminate the thistle seed source, reduce the thistle population, and give an edge to the grasses and forbs the following spring. The problem continued to worsen, however, and a more aggressive course of action became necessary.

In line with the NPS-developed Integrated Pest Management policy, the use of chemical pesticides at Park System sites is carefully controlled. The variety of pest management techniques preferred includes mechanical methods (mowing, hand-clipping, fire) and biological methods (host-specific insects, for example) for controlling pest infestations. These may be used in combination with the approved limited use of chemicals. As the occurrence of noxious weeds is reduced and the grasses and forbs become more vigorous, pest control is maintained by the prairie's own self-perpetuating ecosystem. However, that ecosystem, to be complete, must include fire.

In 1981, the park staff wrote a Natural Resources Management Plan that addressed, in detail, the existing problems in the prairie and suggested alternative courses of action. The plan called for the carefully controlled and limited use of chemical pesticides in order to gain control over the spread of noxious weeds and the reintroduction of fire to the prairie. The park staff worked closely with experts in the field in developing a prairie rehabilitation plan aimed at restoring the natural prairie ecology – a plan aimed at restoring the prairie's ability to take care of itself. Dr. Paul Christiansen, biology professor at Cornell College, Mt. Vernon, Iowa, working with NPS Resource Management Specialist Bill Wilcox, has conducted an inventory of all plant species in the prairie. Other consultants included Jeff Joens, a wildlife management assistant with the Iowa Conservation Commission; Bob Dayton of the Soil Conservation Service; and Ben Holmes and Gary Willson of the NPS Midwest Regional Office. These experts all agreed on the use of fire as an effective management tool in restoring the Hoover prairie.

The absence of fire, probably more than any other single factor, has led to the establishment and maintenance of undesirable species in the prairie. In fact, had it not been for the recurring incidences of natural and man-caused fires in Iowa's grasslands, the soil and climatic conditions would have given rise to forests. Fires through the years have naturally eradicated the woody species before they could establish a stronghold; fire also has perpetuated the native grasses, whose root systems survive the fires and allow for a surge of new growth after the burn.

The Resource Management Plan was approved in 1982. Efforts were continued to remove the seed source of noxious weeds – this time with direct application of a chemical herbicide on the thistles along with hand-clipping of individual plants. At the same time, a prescribed burning plan was developed and preparations were made to implement it.

The reintroduction of fire to the Hoover prairie was accomplished through a prescribed burn in the spring

Scientific input *into the Herbert Hoover NHS prairie management program is provided by Dr. Paul Christiansen, professor of biology at Cornell College, Mt. Vernon, Iowa.*

Interagency Cooperation Produces Sedimentation Study

By Jenness Hall, Brenda Pusso, and Diane Probus

A three-year sedimentation study of the Quantico Creek in Prince William Forest Park was completed in May, 1985. The study, made possible due to an unprecedented team effort between the National Park Service and the U.S. Geologic Survey (USGS), was necessary in order to identify sources and effects of sedimentation within the watershed of the creek.

Prince William Forest Park straddles the fall line, which is the boundary between the Piedmont Province to the west and Coastal Plain Province to the east. The topography is undulating; with narrow ridge tops and relatively steep-sided valleys. The trend of the valleys and ridges is northwest-southeast. The park contains the major portion of the watersheds of the Quantico Creek, and its major tributary South Fork Quantico Creek. The soils drained by the Quantico Creek are easily disturbed, which has led to severe erosion problems. Increased visitor use of the park and development outside the park boundary, including activities on the neighboring Marine Corps Base, have been suspected of increasing the erosion and accelerating sediment deposition in the park's four lakes. The sediment deposited in the lakes has degraded water quality. Two of the lakes have become silt laden to such an extent that they have lost their recreational usefulness.

The need for a study of the sedimentation study processes of the Quantico creek had been realized for sometime. Several years ago, the park approached the USGS to undertake the study. The high estimated cost of the study and a shortage of NPS funds made the work impossible at that time. The development of a proposal to share the study effort resulted, in FY 1983, in the start of the Quantico Creek sedimentation study. The park agreed to supply manpower for data collection and laboratory analysis, to build three gaging stations on the creek, and to purchase some field and laboratory equipment, thus reducing the contract price to a level that could be funded by the Servicewide Water Resources Project Account. Park base funds also paid for the park-supplied manpower and some of the equipment.

The USGS supplied the expertise for the study. They surveyed the Quantico Creek and its tributaries and selected 24 sampling sites, installed staff gages at applicable sites, and selected the study design and methods. While some sites were measured for discharge on both a monthly and storm event frequency, others were measured on a monthly basis only. All sites were measured bi-yearly.

A USGS gaging station was already in operation on the South Fork of the Quantico Creek at the park's western boundary. As agreed the park maintenance staff constructed the additional three permanent gaging stations, bringing the total to four. For each of the stations, the USGS provided an Automatic Data Recorder, which records the gage height at 15 minute intervals, and a graphic recorder, which produces a continuous hydrograph. The latter was helpful in visualizing storm events and in calculating daily sediment load. The park purchased one Manning S-4050

Continued on next page

Prairie Management

Continued

of 1984. The 76-acre tract was divided into five "prairie management units." Three units totaling 46 acres were burned and two units were left unburned to provide a sanctuary for the prairie wildlife and to provide a base for "before and after" comparisons.

The burn prescription had the following objectives:

1. To burn back the trees, shrubs and noxious weeds that generally start their growth earlier in the spring than prairie grasses and forbs.
2. To remove the excess accumulation of litter in the prairie, thus allowing sunlight to heat the earth and encourage the growth of warm-season prairie grasses. (Much of this organic matter, when burned, would be released into the soil to nourish new growth.)
3. To increase and improve habitat for prairie wildlife species.

Following the burn, the areas most heavily infested with weeds were plowed and planted with a rich seed mixture of prairie grasses and forbs. Dr. Peter Schramm of Knox College in Galesburg, Ill., was contracted to provide the native plant seeds and to do the actual planting. He used a Nisbet seed drill, which has proven an effective device for planting native grass seed.

Six months later, a dramatic difference could be seen between the burned and unburned sections of the prairie. The native grasses in the burned area have come back with renewed vigor, standing six to eight feet high in some areas. The Canada thistle, though still present, has been reduced substantially. Dr. Christiansen's post-burn prairie inventory showed the percent cover of Canada thistle in the burned portions of the prairie down from 30.9 percent in 1982 to 16.3 percent in 1984. The plowed areas, as would be expected, have been invaded by a variety of weeds and non-native foxtail grasses. According to Dr. Christiansen, these species should give way to the native grasses and forbs this coming year.

At the same time, Dr. Laura Sweets, a plant pathologist from Iowa State University, has been doing research on certain Canada thistle plants in the prairie that have stunted growth characteristics and are whitish in appearance. These plants are suspected of having a bacterial-like disease known as *apical chlorosis*, which has been found in Canada thistle in very few other areas of the state. Research continues into the implications this may have on noxious weed control.

As for the future, the Park Service plans to continue its prescribed burn program in light of the apparent success of the 1984 efforts. The prairie burned again in April 1985, under the supervision of Chief Ranger Kurt Topham and this practice will continue periodically as part of the natural prairie ecology. In addition, native forbs will continue to be introduced, both through seeding and manual transplanting, to increase the variety of plant species in the prairie ecosystem. The condition of the prairie will be monitored closely and the working relationship with the expert consultants will be maintained.

Robinson, who was a park technician at Herbert Hoover NHS, has been promoted to Supervisory Park Technician at Mesa Verde NP in Colorado.

Fires, both natural and man-caused, *have perpetuated the prairie grasses over the years and halted the encroachment of woody species at Herbert Hoover NHS.*

Sedimentation Study

Continued from previous page

Automatic Sediment Sampler and borrowed several more from the District of Columbia government.

The USGS trained the park's resource management staff to take discharge measurements using a tape measure, calibrated rod, and a velocity meter. Depending on the height and velocity of the water, a pygmy meter or an AA meter attached to the calibrated rod was used. In high flow waters, an AA meter with a 15 or 30 pound weight lowered from a bridge on a handline was necessary. A tape measure was stretched across the creek and the width recorded. The width was then divided into 20 to 25 sampling intervals. At each interval, the distance on the tape measure and depth of water were recorded. Using a stop watch and earphones attached to the meter, the number of revolutions and time in seconds also were recorded.

Each time a discharge measurement was taken, a sediment sample also was collected. In addition, sediment samples needed to be collected at four sites every other day in order to provide base data for the study. This was difficult for the park's small resource management staff to perform on a regular basis. Therefore, members of the park's visitor protection staff, who had expressed an interest or had a background in resource management, were trained to take the samples and incorporated base data sampling into their daily patrols of the park.

An expensive part of such a study is the laboratory analysis of the samples, and project funding was not sufficient to cover all lab costs. Therefore, a laboratory was constructed inside the park. The park's resource management staff was trained by a technician from the USGS Laboratory in Harrisburg, Pa. to perform the laboratory procedure.

Field data were collected from June, 1983 through May, 1985. The USGS has prepared tables of data collected during the project including daily discharge rates and daily sediment loads for the four permanent sites. Graphs showing gage height vs. sediment load and gage height vs. discharge are available for all sites that have staff gages. Graphs showing discharge vs. sediment load are available for all 24 sites. Maps of major drainages and slope erodibility prepared by USGS have already been entered into the park's Geographic Information System to provide a basis on which to develop General Management Plan alternatives regarding suitable locations for trails, fire roads, and picnicking and camping facilities.

The USGS will submit a final report to the park this spring. That report will identify "base flow" sediment which results from natural erosion and indicate where the creek is receiving accelerated sediment loads. It will delineate the time of the year and the types of hydrological conditions that can be expected to produce heavy sediment loads. By identifying sources of sedimentation within the watershed, management action can be implemented at locations where sediment is shown to originate. This will reduce the amount of sediment that enters the lakes.

The U.S. Geologic Survey deserves credit for its flexibility in arranging for this much needed study. Their patience and neverending cooperation is appreciated, as is the assistance of the many others who contributed to this undertaking. It should be noted that a study of this magnitude, even as a joint effort, did require an enormous commitment on the part of the park. That commitment was difficult at times for the park to sustain. However, not only has this innovative agreement made this three year study possible, the park now has the equipment and trained personnel which enable it to continue analyzing the creek's sedimentation load on an ongoing basis. Further, the park has gained a fully operational lab. This kind of cooperative effort, both within parks and with outside organizations, is making it possible to obtain the scientific data on which effective resource management can be based.

Hall is a Resource Manager, Pusso and Probus are Park Technicians.

***Park Service Technician** measures velocity and depth across the creek bed to determine the discharge at that one point in the Quantico Creek.*

***One of the four** gaging stations along the Quantico Creek in Prince William Forrest Park. It houses water level monitoring equipment and an automatic water sampler.*

In the Next Issue

"Island Biogeography and Conservation Strategies" by Peter White

Roundup

Acid Precipitation Research and Monitoring in the NPS

By R. Herrmann

The phenomenon of "acid rain" or, more properly, acid deposition, is widely recognized as a matter of broad public concern. Increased acidity has effects on fish reproduction, has been hypothesized to be responsible for declines in aquatic life in a number of remote Canadian, European and northeastern U.S. lakes, and has been linked to forest decline in West Germany, Central Europe and Eastern U.S. In addition, air pollution is known to accelerate the deterioration of building materials, including historic buildings and cultural monuments.

There are vast differences in the state of our knowledge in the various aspects of acid precipitation research. Much of what we know about the effects of acidification and atmospheric deposition cannot be directly applied to park environments and resources. In reference to parks, we can say: 1) Parks are receiving acidic deposition with loadings highest in the east and southeast; 2) there is a potential for irreversible damage to sensitive cultural and natural resources in parks across the country; 3) these effects could be potentially catastrophic for high elevation lake and stream systems particularly those with salmonid (trout) populations, high elevation boreal forests, and sensitive cultural resources; and 5) the NPS through its strong tie to the interagency research program will get the needed answers over time.

The National Acid Precipitation Assessment Program (NAPAP), was proposed to improve our understanding of the causes, effects and possible mitigation of the "acid rain" problem. The NPS program includes a coordinated and focused set of research, monitoring and assessment activities that emphasize both natural and cultural resources, involving National, Regional and Park Staff (Table I). Natural resources research supported through NAPAP began in FY '82-'83 in Isle Royale, Sequoia/Kings Canyon, and Rocky Mountain National Parks and in FY '84 in Olympic NP. Currently, NPS is cooperating through the interagency task force with the EPA, USDA, USGS, and US Fish and Wildlife Service to study the sensitivity of natural resources in the parks. Since 1980 the Service has established and operated National Atmospheric Deposition/National Trends Network (NADP/NTN) "acid rain" monitoring sites in 26 NPS areas and during FY '85 in cooperation with BLM has added 2 additional sites.

Cultural resources research is focused on determining cause and effect links between atmospheric deposition and deterioration of historic materials, particularly marble, limestone, and statuary bronze. This effort includes laboratory research, and in situ monitoring of cultural resources in parks, and controlled field exposures at several sites selected to represent the range of potentially impacted environments. Long-term research sites have been established at Mesa Verde NP in Colorado at Independence National Historic Park in Pennsylvania. Additional sites will be added in future years. NPS research has begun to identify sensitive cultural resources in the U.S., both in parks and privately owned historic properties. Finally, laboratory and field research is underway to evaluate potential strategies to protect cultural resources from damage that results from acid deposition.

Deposition Monitoring

The NAPAP operating research plan states that documenting the temporal and spacial trends of the chemical composition of atmospheric deposition in the United States is fundamental to assessing the problem of acid deposition. The National Trends Network (NTN) in which NPS participates is designed to provide a record that will allow the detection of chemical trends in atmospheric deposition. The network is operated consistently nationwide, and data collected are stored in a single computerized data base that is available on request. Wet deposition (rain and snow) is presently monitored at 150 wet deposition monitoring sites nationwide. Each site is considered to be representative of precipitation over a broad region as sites are required to be located to minimize significant influence of local atmospheric emission sources. Plans to monitor dry deposition (gases, aerosols, and particulate matter) on a pilot scale will be implemented beginning in 1986.

At present wet deposition samples are collected weekly and analyzed for major cations, anions, pH and acidity at the Illinois Water Survey, Central Analytical Laboratory. Data are presented in the form of national scale maps of concentration and deposition. Operation of NTN sites will extend to FY '92 and beyond as long as the need for information remains. Long-term monitoring of the chemistry of atmospheric deposition is being conducted at 28 NTN/NADP sites by NPS in cooperation with USGS (Table II). BLM, NOAA and state agencies. Data available at the National Park Service operated and maintained sites for the period of record are too short to draw any conclusions.

Table 2
NPS Areas Operating NADP/NTN Atmospheric Monitoring Sites

1. Denali (McKinley) NP, Alaska
2. Grand Canyon NP, Arizona
3. Buffalo River NP, Arkansas
4. Organ Pipe Cactus Nat'l. Mon., Arizona
5. Yosemite NP, California
6. Sequoia-Kings Canyon NP, California
7. Rocky Mountain NP, Colorado
8. Everglades NP, Florida
9. Isle Royale NP, Michigan
10. Glacier NP, Montana
11. Theodore Roosevelt NP, North Dakota
12. Great Smoky Mountains NP, Tennessee
13. Big Bend NP, Texas
14. Shenandoah NP, Virginia
15. Olympic NP, Washington
16. Yellowstone NP, Wyoming
17. Indiana Dunes NL, Indiana
18. Mesa Verde NP, Colorado
19. Cape Code NS, Massachusetts
20. Hawaii Volcanoes, Hawaii
21. Craters of the Moon NM, Idaho
22. Acadia NP, Maine
23. Guadalupe Mountains NP, Texas
24. Custer Battlefield NM, Montana
25. Lehman Caves NM, Nevada
26. Capulin Mountain NM, New Mexico
27. Bryce Canyon NP, Utah
28. Bandolier NM, New Mexico

Park Studies

The National Program of studies, as a component of NAPAP, expands the nationally available data base by emphasizing ecosystem studies. To accomplish this the National Park Service has established a limited number of research sites which correspond to

Continued on next page

Table 1
NPS Acid Precipitation Research Activities (to 1985)

Area	NPS/Univ	Region	Effects (Terrestrial Air Water)
Acadia NP	U Maine/College of the Atlantic	NA	Surface waters
Cape Cod	U Wisconsin	NA	Paleo-limnology
Cape Cod	NPS	NA	Salamanders
Mt. Rainier	NPS/USGS	PN	Lake water chemistry
Shenandoah	U Virginia	MA	Stream & water-shed acidification
Delaware Water Gap	Rutgers University	MA	Lakes chemistry
Mt. Catoctin	USGS	MA	Calibrated watershed
Isle Royale	NPS/Met Tech University	MW	Long term watershed & ecological study
Great Lake Basin Parks	NPS	MW	Long term water quality monitoring
Great Smoky Mountains	EPA/TVA/EPRI/NPS	SE	Water chemistry, stream effects, forest effects
Blue Ridge Parkway	NPS	SE	Forest effects
Rocky Mountain	NPS/USGS/CSU	RM	Lake & soil chemistry, long term ecological research
Yellowstone, Glacier & Rocky Mountain	USFWS/NPS	RM	Surface water sensitivity survey
Sequoia NP	NPS/USGS/CA State NASA/USDA/U of Ca	WR	Long term ecological research
North Cascades	NPS/USGS	PN	Lake water chemistry
Olympic	NPS/U of Wash/U of Ore	PN	Long term ecologica baseline research
Mesa Verde	NPS/U of Ill/ASU	RM	Long term ruins monitoring
Independence	NPS/Airline & Assoc.	MA	High resolution photogrammetry
Washington, D.C.	NPS/USGS	NC	Detailed deterioration, stone decay in monuments

nationally representative ecological regions along the deposition gradient from east to west. Sites include the "cleanest" continental area (Olympic NP) with little potential for serious impact as well as areas (Sequoia NP, Isle Royale NP, Rocky Mountain NP) that, while still thought to be relatively unimpacted, contain places and resources highly sensitive to acid precipitation. Our intent is to obtain a basic understanding of the structure and function of these ecosystems relative to anthropogenic atmosphere deposition. In order to achieve these broad goals it is necessary that each study site collect a prescribed set of information to address selected core questions. Another use of these data is to answer ecologically important questions about system response. These measurements emphasize background data acquisition required for analysis and that will be of value for inter-site and intra-site comparisons.

The core requirements are intended to provide information necessary to address the following objectives:

1. Quantify seasonal inputs of atmospheric deposition in the form of rain and snow.
2. Take steps to initiate the monitoring of dry deposition, including ozone, sulfur dioxide, nitrogen oxides, particulates, and quantify potential impacts of dry and wet deposition.
3. Characterize local climatological parameters.
4. Establish a long-term data base for detection of variations in surface water chemistry.
5. Establish a long-term data base on the biology (composition, structure, phenology and population dynamics) of selected plant and faunal population thought to be potentially sensitive to acid deposition.
6. Develop watershed (input/output) measurements for water and selected inorganic chemical constituents.

Our approach is based on the precept that ecosystems undergo long-term change in response to incremental alteration by natural and anthropogenic factors. Relatively few studies underway in North America will have the longevity necessary to detect the often subtle effects of such factors in natural ecosystems. As a component of the National Acid Precipitation Assessment Program, the National Park Service's ecosystem studies program can make a unique and significant contribution. Units of the National Park System encompass a diverse array of the nation's ecological diversity and the natural resources within these units are protected in perpetuity by law. As a result most are relatively undisturbed and many contain outstanding examples of mature ecosystems. Those with disturbed sites became such due largely to natural perturbation and represent successional ecosystems. Such conditions provided a unique opportunity to undertake long-term ecosystem studies.

The long-term management goals and the protected nature of the National Park System provide a unique basis for long-term studies to develop the background information against which to document relationships between ecosystem effects and atmospheric deposition of potentially toxic substances. In this way the NPS program makes it possible to assess the nature of changes in representative unmanipulated and protected ecosystems and provides a basis for comparison with the efforts of other agencies such as the National Lake Survey, National Terrestrial Survey and National Soils Survey.

Herrmann is Chief of the Applied Research Branch of the NPS Water Resources Division in Fort Collins, CO.

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