PARK SCIENCE
Integrating Research and Resource Management

Volume 16 – Number 3 National Park Service • U.S. Department of the Interior Summer 1996

The Natural Resource Trainee Program: Professionalization Triumph of the 1980s and Early 1990s

Who are they and where are they now? *See the key on page 17 to identify these participants of the first Natural Resource Trainee Program and learn what they are up to now.*

By the editor

THE NEED TO ESTABLISH AND PROFESsionalize science and resource management functions and apply them in the management of national parks was recognized as early as the 1930s. Then, biologist George Wright published several papers on wildlife management and made the clear connection between science and informed park resource management activities. Yet, for the next 5 decades, resource management work continued to be done mostly by park rangers who were trained primarily in law enforcement and other operational areas, not necessarily in an applied science. In 1976, Bandelier National Monument Park Ranger John Lissoway, involved in park visitor protection training at the time, recognized the lack of a natural resource component to round out his training. Southwest Regional Chief of Resource Management Ro Wauer suggested a resource management training component be added.

Working within the scope of the IDP (Individual Development Plan) program–a NPS training needs and personnel development tool–Lissoway and Bandelier Superintendent John Hunter identified park resource management needs and translated them into concrete training requests. Each training need was product oriented, bringing direct benefit to the park. To achieve Lissoway's natural resource training goals, they identified training advisors–often from other agencies, the private sector, or universities–who would be the primary sources for imparting the skills. Regional office funding allowed parks to send staff to the training and backfill behind them to take care of unfinished park work. Other superintendents soon heard about the training opportunity and wanted to be a part of it. Wauer then prioritized individual park needs, opting for placing resource management trainees at parks that formerly didn't have any resource management expertise.

The program went national in the early 1980s following publication of two different conservation organization reports on threats to national parks and a response by the National Park Service in the form of a state-of-the-parks report. Having a surprisingly deep impact, the latter report prompted Congress to direct the National Park Service to identify potential remedies to the threats it so capably identified. One of those remedies was to train staff in professional resource management techniques and get them out to the parks with the greatest needs. Called the Natural Resource Trainee Program, the initiative was patterned after the pilot training efforts developed in the Southwest Region. Having moved to the Washington office, Wauer became the primary coordinator for the new course along with the help of Southwest Regional Chief Scientist Milford Fletcher. Seeking to place 30 trained resource managers in high priority parks each time the course was offered, the first 2-year class began with 36 trainees in August, 1982 (see the key to the cover photograph and Table 1 on page 17).

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The editor encourages submissions from all readers and would especially like to stimulate resource managers to write for the Highlights column. See current submission guidelines on page 5. Contact the editor at:

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IN THE NEXT ISSUE. . .

This fall, we will take a look at the status of resource management for lepidoptera (moths and butterflies) in northeastern parks; a process to assess the condition of riparian and wetland areas; results from the Park Science reader survey; accounts of new paleontological finds in two parks; a new process for evaluating park construction proposals that benefit natural resource preservation; property rights to genetic resources; and a review of the book, Wildlife Policies in the U.S. National Parks.

On Being Prepared

As you may know, President Clinton recently announced a land swap between Canadian-held Crown Butte Mines, Inc., and the federal government, effectively killing the proposed New World Mine near Yellowstone. Had it gone through, this project would have developed an underground mining process to recover gold, silver, and copper from a mountain near the park's northeast boundary. The controversial project had the potential for long-term contamination of Soda Butte Creek in Yellowstone and also endangered the Clark's Fork of the Yellowstone River, a federal wild and scenic river.

The high-level deal did not come by politics alone and it did not come overnight. It was based on a steady stream of technical information and reasoned analysis that has been flowing from scientists and resource managers to park administrators and political representatives for several years. Certainly, the proposed mine was also an emotional issue, but geologists, biologists, hydrologists, and water resource specialists played the central role in making the scientifically based case against the project. They even suggested the land swap.

Not all threats facing parks are as prominent as this, yet the process to deal with them involves the application of information gained through research. This relationship, the core of this publication, is illustrated throughout this issue in articles that span the continuum from documenting park resources to resource manipulation.

We cannot possibly predict all threats to the natural resources in our care, but we can prepare for some as Toben Lafrancois points out in his article on the diverse aquatic life in rock pools at Capitol Reef National Park. A part of his study involved a resource inventory process, a fundamental building block for resource preservation that is the basis from which so many other resource activities are based. We also need to be prepared to examine our work critically from time to time and make midcourse corrections. Laurel Last and Richard Whitman share suggestions on this subject in their examination of the water quality monitoring program at Sleeping Bear Dunes National Lakeshore. Demonstrating the possibility of a strong marriage between science and interpretation, Jeff Marion and Susan Brame bring us up to date on the *Leave No Trace* backcountry ethics education program that is having success in minimizing impacts to wilderness.

If, as Louis Pasteur suggested, chance favors only the prepared mind, then nowhere is preparation more important than in our own workforce. As the lead article details, the Natural Resource Trainee Program was a successful investment in the future of NPS natural resource management. As a result of that course and a similar one just begun, we are continually preparing to handle future unknowns like the New World Mine.

Jeff

News & Views

Director Kennedy Honors Natural Resource Stewards

National Park Service Director Roger Kennedy recently announced the 1996 winners of the prestigious Director's Award for Natural Resource Management. Given annually, the awards recognize and foster outstanding contributions to natural resource management and research. The honorees include a NPS park superintendent, a NPS resource manager, and a federal government scientist whose work supports park natural resource preservation. The awards were presented at a ceremony in San Francisco in August. All winners received a plaque and a $2,500 monetary award.

Superintendent of the Year for Natural Resource Stewardship

Bryan Harry, Superintendent of the Pacific Island System Support Office, is the recipient of this award, which recognizes innovative resource management and support by a NPS superintendent. An outstanding leader, Bryan has demonstrated an ability to protect and restore native ecosystems in Hawaii and the Pacific islands during the last 25 years. His influence has resulted in realistic prospects for conserving highly significant vestiges of native Pacific ecosystems. As Superintendent of Hawaii Volcanoes National Park from 1970-1974, he and his staff changed the mindset in Hawaiian parks from accepting "inevitable" resource deterioration to proactive management that reverses deterioration and restores biological diversity. Upon returning to the islands as Pacific Area Director from 1982 to the present, Bryan presided during an era of tremendous progress in coping with resource issues in Hawaiian parks and expanded proactive management to parks throughout the Pacific.

"I am happy to accept this award," Harry stated, "because it recognizes the accomplishments of park crews and resource managers working with the cooperative park studies unit (CPSU) to mitigate the impacts of nonnative species in the Pacific Island parks. The 'mindset' we changed was to integrate the work of resource managers, park crews, and the scientists at the CPSU. We also shifted our concept of measuring success from how many alien animals we killed to basing removal decisions and efforts on the overall impacts the nonnative species have on the native populations. We have had some success, particularly with large mammals, but have lost the avifauna on Guam to a tree snake. Another difficult area is fire-adapted nonnative grasses." Harry continued, "Hawaii may be providing the national park system with a taste of things to come. While island ecosystems are the first to feel the severity of effects of nonnative species, I think the mainland will face the same challenges in the future; the mainland is just a bigger island."

Natural Resource Manager of the Year

Terry Hofstra was chosen for his contributions in guiding the Redwood National and State Parks resource management staff as they forged important working relationships between neighbors, parks, and private entities. A leading proponent

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and facilitator of interagency and intra-agency and private sector cooperation, Terry has helped the parks advance toward ecosystem management. Using this approach, the parks have been able to address a broader range of issues over the past 6 years. Pleased to be recognized, Hofstra pointed out that "an award like this is an indication that the entire staff is effective in working toward park preservation goals."

One of the largest resource management operations in the national park system, this staff of more than 40 have concentrated on restoration activities, including mitigating erosion, as a result of logging. While 170 miles of logging roads within the park have been restored under his leadership, an additional 3,000 miles of roads within the watershed have the potential to cause severe erosion and damage to park resources downstream. Hofstra's staff, including archeologists, fish and wildlife biologists, botanists, ecologists, geologists, hydrologists, fire specialists, and maintenance and administrative personnel, have slowly begun to garner the trust and interest of the neighboring private landholders and have started to inventory the condition of the roads in the watershed. A measure of their progress is that the park is now routinely invited to review logging plans *before* they are filed and is able to address park concerns before logging or other activities on adjacent private lands begin. To aid in communication between the partner parks, Hofstra has also helped arrange for a full-time state parks resource manager to be integrated into the operation.

Hofstra has also applied the principles of managing the complete range of resources into a cohesive, large-scale program that includes wildlife management and planning. Redwood National and State Parks are home to the endangered Marbled Murrelet, an ocean-feeding bird that nests atop old-growth trees. When an adjacent landowner recently petitioned the U.S. Fish and Wildlife Service for a permit to log the remaining 564 acres of old-growth redwood from its property, Hofstra, ironically, foresaw the potential for long-term benefit to the murrelets within the park. By preparing a second-growth forest management plan in the interim, the parks are now poised to accept funds, mandated by the Endangered Species Act, to counter habitat disruption from the logging company. If its request for a permit is approved, the firm would pay for thinning 10 acres of second-growth forest within the parks for every acre disturbed on private land. Thinning a second-growth forest increases the speed by which the woods return to old-growth, providing increased future habitat for murrelets. If this comes to pass, Hofstra sees it as "a timely and much needed example of the flexibility of the Endangered Species Act in providing for endangered species preservation while accommodating some commercial activities."

RESEARCH

This award is given to the federal employee who has made the most significant scientific contribution to the NPS natural resource program through the development of creative research projects, published research, or the initiation of science programs. Dr. Paul A. Buckley, Senior Scientist (Ecology) with the National Biological Service Cooperative Park Studies Unit at the University of Rhode Island, was recognized for research and natural resource preservation accomplishments that have greatly assisted the National Park Service in achieving its preservation goals. His personal research program, leadership in many areas of natural resource preservation, and influence on national preservation policy span nearly 25 years in association with the National Park Service.

"Winning this award is extremely satisfying, because my colleagues and I have been very persistent over the years pursuing what we knew were critically needed park research projects," Buckley commented. "Nearly all of my own research," he continued, "has been management driven. I have been entranced, captivated by great personal satisfaction from the successful application of research results to park management."

Buckley enjoys tackling some of the most vexing research questions today–those that involve looking at the interplay between various resource recreation uses and their impacts on the population numbers and health of plants and animals. His expertise in this regard is population biology of shorebirds and the biodiversity of birds throughout the northeastern national parks. His work typically results in providing information to managers who must make difficult decisions about resource protection and visitor use.

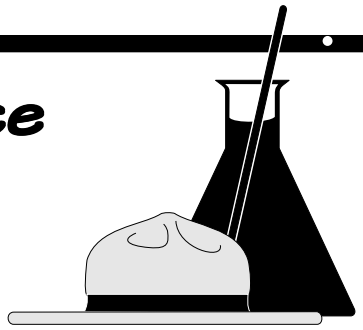
Working as a shorebird ecologist in the late 1970s, Buckley assisted the National Park Service in gaining colonial waterbird and Piping Plover habitat protection in the face of numerous beach nourishment projects proposed by the U.S. Army Corps of Engineers along Fire Island National Seashore, New York. In addition, Dr. Buckley is still involved with investigations he initiated in the 1980s concerning the interrelationships among waterbirds, including Laughing Gulls in the Jamaica Bay Wildlife Refuge Unit of Gateway National Recreation Area, and aircraft on the adjacent John F. Kennedy International Airport. Buckley also began funding and doing some of the first work on the ecology and management of Piping Plovers, an endangered eastern U.S. bird species that, thanks in large measure to NPS management in coastal parks and seashores, is now making a comeback. He is quick to warn, however, that "if we make poor decisions [regarding uses of plover nesting beaches], recovery could be set back in a hurry."

While Dr. Buckley acknowledges the importance of applied research in meeting park management needs, he also observes that "there is tremendous need for much more site-specific inventory and general ecosystem research in our parks. Such research might not have obvious immediate application, but is nonetheless essential to the long-term management of the natural resources under our care."

Moving away somewhat from the kinds of projects he has worked on over the last 25 years, Buckley is currently involved in a massive, 5-year, multi-investigator study at Fire Island quantifying, for the first time, the relative roles of migratory and resident birds, deer, small mammals, and ticks, in the ecology of Lyme disease. Here, too, he has succeeded in maintaining that elusive, but critical mixture of research that is at once the most basic, and yet still the most applied.

Save for future reference

Writing for Park Science



Publication Overview

What is Park Science?

Park Science is a quarterly, 32-page, research and resource management bulletin of the National Park Service of the U.S. Department of the Interior. The publication strives to strengthen the links between research and park management. Articles describe both experiments that relate to resource conservation and the application of science in resource management practices. Technical in nature, *Park Science* is edited for the educated lay reader. It is published four times per year (April, July, October, and January) and is also available on the Internet World Wide Web at *http://www.aqd.nps.gov/nrid/parksci*.

What Kinds of Articles are Published in Park Science?

Park Science articles are popularized, field-oriented accounts of general interest research and resource management topics. Articles consist of case studies (specific park-applied research and resource management project write-ups), feature stories (personalized reports on research and its application or professional growth experiences), and short stories (brief articles of broad interest and applicability). Repeating columns include editorials (relevant opinions about current trends in research and resource management), Information Crossfile (synopses of longer, often scholarly works relevant to resource managers), Meetings of Interest (a calendar of important upcoming conferences), Notes from Abroad (accounts of international resource management and research experiences), Man and Biosphere Notes (a report on the MAB program of UNESCO), book reviews and profiles of new publications, 15 Years Ago in *Park Science* (a look back at an earlier story), and Highlights from around the national park system.

Questions

The following guidelines should clarify most of the submission criteria for case studies, feature-length articles, and cluster highlights. However, please contact the editor if you would like to discuss these guidelines in more detail or if you would like help in developing a specific story.

Case Study and Feature Article Submission Guidelines

Focus and Tone

Case studies and feature articles should emphasize the implications of natural or social science research for the management of natural, cultural, and human resources. A broad readership calls for clear communication–highlight main concepts, explain project significance and methods, and detail applicability to management. Write primarily in the active voice and explain technical terms.

Target Audience and Primary Authors

Principal readers and contributors comprise national park system area superintendents, resource managers, natural and social science researchers, interpreters, maintenance staff, visitor and resource protection rangers, and other technical and nontechnical personnel. Circulation also includes other federal agencies; state departments of fish and game, parks and recreation, and natural resources; international parks; private conservation organizations; the academic community; and interested public.

Criteria

Feature articles and case studies may include (1) a description of the resource management problem(s) that prompted the research; (2) an explanation of the significance of the resource management project; (3) discussion of management considerations related to the problem(s), such as relevant legislation (enabling, NEPA, ARPA, Endangered Species Act, etc.), pertinent park planning documents (GMP, SFM, FMP, RMP, etc.), planning procedures, and political considerations; (4) a summary of the methodology of the experiment; (5) the results and ramifications of resource management implementation options; (6) a description of how the findings were applied in the field; and (7) an appraisal of the scope of applicability of the findings to other park areas. As additional information about a project accrues, follow-up reports (one or more years later) may be very useful in fine tuning conclusions.

Length

Flexible, but aim for 1,500 words.

Author Information

In addition to a byline, include position title, park area or affiliation, a brief biography, work address, phone and fax numbers, and e-mail address.

Measurements

Report measurements in metric (using abbreviations for units) followed by English in parentheses. Time is to be reported using A.M. and P.M.

Deadlines

Fall issue–August 1; Winter–November 1; Spring–February 1; Summer–May 1.

Illustrations

Submit several illustrations. Show personnel at work, project equipment, techniques used, locator maps, species portraits, etc., to illustrate the major points of the article. Color slides (35mm) are best, but original line art, photostats, high quality photocopies, black and white photographic prints (glossies preferred), and color prints are also acceptable. Computer-generated illustrations (i.e., scanned art, ArcView maps, etc.) can be forwarded through cc:Mail, on floppy disc, or on laser-printer originals

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Guidelines revised August 21, 1996

(600 dpi if possible). Include the name of the artist or photographer and documentation of approved use if the illustration is copyright-protected. Label each illustration with park name, article title, any placement information (e.g., fig. 1), and the file format (e.g., TIF, EPS, etc.).

Captions

Include a description for each illustration that describes the relationship of the illustration to the theme of the article.

Delivery

Send contributions to the editor using these methods in priority order:

(1) by cc:Mail with the word-processed document and any illustration files attached. Indicate the word-processing software and version in the cover message (e.g., WordPerfect 5.1);

(2) over the Internet. First save the word-processed document as a text file (i.e., *.TXT);

(3) by fax. Use double-spaced, laser-printed originals if possible. Illustrations may not be faxed.

(4) by mailing the hard copy (double-spaced) and a floppy disc containing the word-processed document (indicate the software and version) and any illustrations;

(5) by mailing the double-spaced hard copy (laser-printed originals if possible) and any illustrations alone;

Review Procedures

Prior to submission to the editor, submit courtesy copies to both the area manager (superintendent) for policy considerations and the appropriate associate field director for natural resource stewardship and science. The editor and editorial board review articles for general appeal, relevance, usefulness, technical credibility, solution-oriented discussion, and agreement with submission criteria. Following editorial review, the editor will contact the author to discuss revisions and finalize the article.

Contributing to the *Park Science* Highlights Column

Content

The Highlights department presents an overview of the diversity and complexity of research and resource management work undertaken by the National Park Service on a cluster by cluster basis. An entry may, for example, summarize a research or resource management project; detail a noteworthy accomplishment; relate a new development, technique, or trend; discuss a challenge or complication; describe project implementation under a national resource management initiative; or profile a principal investigator. Ideally, these synopses focus on work conducted at parks rather than at the system support office in support of parks. In many cases, highlights items would make terrific feature articles, but are presented in brief as a snapshot of the research and resource management work being accomplished cluster by cluster.

Focus and Tone

Submissions should be written in lay language in the active voice. Include names of personnel and the areas featured in each entry. Strive to briefly answer the who, what, why, when, where, and how questions about the story. Stress the relationship of the subject to either a resource management or planning problem or to the state of the art of the discipline being discussed.

Length and Number of Entries

Entries vary greatly in length from 50 to 350 words, but average 200 words each. Cluster highlights contributing editors are encouraged to submit at least one entry every other issue. Unsolicited submissions from the field are also welcomed as contributing editors may not always supply material.

Illustrations

Illustrations including line art and photographs are welcomed, but are not required.

Deadlines

The deadlines for Highlights submissions are: Fall issue–August 1; Winter–November 1; Spring–February 1; Summer–May 1. Late contributions are welcome, but may be held for subsequent issues.

Delivery

Contributions may be sent to the editor via several means. CC:Mail is most convenient for the editor. Simply attach your word-processed file to your cc:Mail cover message.

Contacting the Editor

Cut out and place in your Rolodex

Park Science

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NEW BIODIVERSITY PUBLICATIONS

THE WORLD RESOURCES INstitute has released several new publications on biodiversity:

National Biodiversity Planning: Guidelines Based on Early Experiences Around the World by Kenton R. Miller and Steven M. Landou is a practical handbook that offers background information, case-study examples and analysis, and step-by-step guidelines for planning and implementing national biodiversity strategies and action plans. Intended for use by government, communities, business and industry, and nongovernmental organizations, it presents an illustrative biodiversity planning process based on the real world experiences of 17 regions–Australia, Canada, Chile, China, Costa Rica, Egypt, Germany, Indonesia, Kenya, Mexico, Holland, Norway, the Philippines, Poland, the South Pacific, United Kingdom, and Vietnam– that are already developing national strategies, plans, and programs. The book (ISBN 1-56973-025-3) is 200 pages long, costs $19.95, and is published in collaboration with IUCN and the United Nations Environment Programme.

Kenton Miller has also authored *Balancing the Scales: Guidelines for Increasing Biodiversity's Chances Through Bioregional Management* through the World Resources Institute. This work addresses the worldwide effort to protect biodiversity by setting aside discrete areas for conservation and the problems that accompany this strategy due to the demands of growing human populations in need of more land and resources. As a result, scientists, resource managers, and community leaders are calling for shifting the scale of wildland management programs from national parks and reserves to entire ecosystems. This book makes the case for protecting biodiversity wherever it is found: in farmlands, utilized forests, fisheries, and not just within the boundaries of protected areas. Drawing on case studies from Yellowstone, the Serengeti, the Great Barrier Reef, the Costa Rican La Amistad Biosphere Reserve, and other sites, the author explains the challenges and opportunities of *bioregional* management. Aiming at policy makers and practitioners, he brings light to the core elements of successful projects: building capacity to manage larger, more complex areas; forging negotiated agreements with resource users and other stakeholders in the bioregion; and developing cooperation and support for bioregional programs among area institutions. The book (ISBN 0-915825-85-6) costs $14.95 and is 150 pages in length.

Biodiversity Indicators for Policymakers is a paper that provides a framework for assessing biodiversity conditions and trends at local, regional, national, and global levels. Written by W.V. Reid, J.A. McNeely, D.B. Tunstall, D.A. Bryant, and M. Winograd, it presents 22 indicators that can guide conservation decision making by helping planners to set priorities, influencing new policies, and providing information to determine whether policy goals have been achieved. Organized into three categories, the indicators measure: wild species and genetic diversity; diversity at the community-habitat level; and diversity of domesticated species (crops and livestock). The paper (ISBN 0-56973-000-8) is 42 pages long and costs $12.95.

Finally, *Biodiversity Prospecting: Guidelines for Using Genetic Biochemical Resource Sustainably and Equitably* argues that biodiversity prospecting ventures (as in the case of Yellowstone hot water organisms reported on last issue) will not succeed if they do not promote sustainable development. The authors focus on three institutional elements that will ultimately determine the course of this new industry: organizations, contracts, and national legislation. With detailed chapters on designing institutions to facilitate biodiversity prospecting; biodiversity prospecting contracts; intellectual property rights; research management policies; and science and technology guidelines, this report provides the most comprehensive and strategic analysis to date of what may be a significant growth industry in the 21st century. Available from the World Resources Institute for $29.95, the book (ISBN 0-915825-89-9) is 340 pages in length.

The World Resources Institute is an independent research and policy institute founded in 1982 to help governments, environmental and development organizations, and private business address a fundamental question: how can societies meet basic human needs and nurture economic growth without undermining the natural resource base and environmental integrity?

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NATIONAL CAPITAL

New Species Documented in *Bio-Blitz*

For 24 hours starting at 5 p.m. on May 31, local scientists, naturalists, and biologists "blitzed" Kenilworth Park and Aquatic Gardens in northeastern Washington, D.C., and found approximately 1,000 species of plants and animals. The idea was to inventory, as far as possible, the species present (and identifiable) during one 24-hour period. The information will be used for a number of purposes, including the continued development of the park inventory and monitoring database and the development of plant and animal lists for the newly created District of Columbia Natural Heritage Program. The activity also demonstrated the concern scientists have for local biodiversity, and gave the National Park Service an opportunity to heighten media and public awareness of the many species that can be found even in a highly urbanized area such as Washington, D.C.

The event went extremely well with participation by at least 25 different agencies (federal, state, and local government), universities, and various conservation. To date, the results from the lab and field work have provided many new records for the park, which include new species of dragonflies (2), damselflies (5), butterflies (2), birds (2), bats (2), earthworms (6), copepods (16, 10 of which have never been recorded within the District of Columbia), fish (1), lichens (10), mushrooms (7), land plants–embryophytes (95), and arthropods (insect groups not already listed–approximately 650 new records). In addition to the new species records, the event was a wonderful opportunity to meet and join efforts with local scientists, naturalists, and biologists. In the future, the park will know who to contact for additional assistance and staff expect some of these participants to return to parks that comprise the National Capital Parks-East for future projects.

Readers may review the Washington Post newspaper article, inventory lists, and additional details of the event through the Internet web site set up for the Bio-Blitz at http://www.im.nbs.gov/blitz.html or by contacting Dan Roddy of the National Park Service at daniel_roddy@nps.gov or Sam Droge of the National Biological Service at frog@nbs.gov.

ALLEGHENY-CHESAPEAKE

Natural Resource Bibliography Project Summarized in Poster Session

Scott Tiffney, in association with Dr. Richard Yahner and Kathy Derge (The Pennsylvania State University) and John Karish (National Park Service), presented a poster entitled "Natural Resources in Our National Parks" at the 1996 Annual Conference of the American Library Association held in New York City. The poster outlined the development of a comprehensive natural resource bibliography database for the Chesapeake and Allegheny park clusters as part of a cooperative project between the National Park Service, The Pennsylvania State University, and North Carolina State University.

GREAT LAKES

Mussel Relocation Study Under Way

In late July, St. Croix National Scenic Riverway, WI, began relocating freshwater mussels to similar habitat in the same watershed as part of a study to determine the long-term effectiveness of translocation as a conservation measure for endangered mussels and to refine existing translocation protocols. Native bivalves throughout the Midwest, South, and Northeast are threatened by an infestation of the nonnative zebra mussel *(Driessena polymorpha)*. Funded by the National Park Service and directed by the National Biological Service (Dr. Greg Cope and Dr. Diane Waller), the project resulted in the relocation of 450 native mussels into a refugium in the NPS managed zone of the St. Croix River.

Two federally-endangered species, the Higgins' eye pearly mussel (*Lampsilis higginsi*) and the winged mapleleaf mussel (*Quadrula fragosa*) and 15 state-listed species reside in the St. Croix, which supports one of the most diverse communities of native mussels in the Upper Mississippi drainage. The information derived from this study will also be used nationally to establish appropriate methods for conducting mussel relocation projects based upon long-term monitoring results (Cope and Waller, 1995).

Two species of unionid mussels representing the subfamily Ambleminae (pimpleback, *Quadrula pustulosa* and spike, *Elliptio dilitata*) and one representing the subfamily Lampsilinae (Higgins' eye pearly mussel) were collected from the St. Croix River by divers under federal endangered species permits. The 450 mussels were relocated to three underwater 5x5 meter (16.4 x 16.4 ft) study grids, two of which are located in the experimental refugium, upstream, and one that served as a source-site control grid located in the collecting zone. The upstream location supports an existing diverse population of mussels, including the only known world population of the winged mapleleaf. Surrogates to the winged mapleleaf were used in the initial phases of this study rather than risk handling the species itself. The refugium is located upstream of a navigation control site established to regulate boat traffic to vessels that have not been operating in zebra mussel infested waters.

River substrate characteristics, mussel density, species richness, and live:dead ratio data were collected at each grid site. Mussels were measured, weighed, aged, sexed (for the federally-listed species) and uniquely marked prior to transport. Research staff placed the mussels in flow-through tanks that were temperature monitored prior to processing and transported in ice-cooled chests. A quantitative assessment of mussel survival, growth, and substrate characteristics will be made annually for a minimum of 2 years.

Native mussels are the most rapidly declining faunal group in the United States, and freshwater mussels constitute the largest group of federally listed endangered or threatened invertebrates. The St. Croix River supports 38 species of unionid mussels, including the only reproducing population of two federally listed species that are not impacted by the zebra mussel. This project is important in protecting the mussels of the St. Croix and in providing criteria for relocating mussels.

GREAT PLAINS

Homestead Cleans Up Following Tornado

On the night of May 8, a tornado ripped through 10 acres (4 ha) of Homestead National Monument of America, Nebraska, damaging park and neighboring homes, and scattering an estimated 114 tons of wind blown debris over 30 acres (12 ha) of park tallgrass prairie. No deaths or serious injuries resulted from the storm, but the high winds damaged trees, fences, signs, and homes in and adjacent to the park sending fiberglass insulation, wire, plywood, structural beams, drywall, asphalt shingles, and personal items across park lands. In some areas, the debris was 5-10 pieces thick per square foot.

The Homestead tallgrass prairie is a restored cultural landscape that interprets the scene as it appeared prior to the homestead movement of the 1860s. Established in 1939, the 100 acre (41 ha) prairie is the oldest such restoration in the national park system. The debris posed a safety threat to visitors and impaired the prairie itself as the spring growing season began. Immediately, park staff needed to determine the best method of clearing the debris.

At the time, the prairie grasses were 2-3 feet high and the debris was either hard to see or tangled in the grass and emerging forbs. The park posted a message on the NPS cc:Mail Natural Resource Bulletin Board in an attempt to solicit suggestions and accounts of experience dealing with similar circumstances. Among the 25 replies, a few recommended prescribed fire as a remedy; others suggested raking or just leaving the debris; several suggested using volunteer labor.

Though the park identified few hazardous materials, burning was not the preferred alternative due to the proximity of private homes, the presence of asphalt and fiberglass, and the possible encouragement of exotics resulting from burning late in the spring. Raking was impossible due to the terrain, debris materials, and type of vegetation. Using heavy trucks was also impractical due to the long-term damage they would cause from soil compaction. Leaving the debris was not an option and after considering all suggestions, the park decided that hand labor was the only alternative that would allow staff to collect the maximum debris with minimal impact.

After surveying the affected area, employees estimated that about 2,000 hours of labor would be needed to conduct the cleanup. At the time, monument staff consisted of eight permanent employees with no funds for seasonals. Considering the nature of the debris and its effect upon the rapidly growing prairie plant life meant that clean up needed to commence without delay. Continuing rainstorms matted debris into the vegetation as staff began the massive pickup, and they immediately realized they needed considerable outside help.

Using local and regional media, the park proclaimed June to be "Homestead Cleanup Month." Volunteers responded almost immediately. Civic organizations, other agencies, families, and individuals generously donated their time to work under the supervision of park staff and do whatever was needed to clear the debris. To maintain park operations, the park limited the volunteer cleanup effort to 4 days a week. All volunteers received a park orientation and safety flyer when they arrived and a certificate of appreciation for their service. The presence of dangerous materials (nails, glass, etc.) led the staff to restrict participation to volunteers of 16 years of age or older. Furthermore, they checked all volunteers for gloves and boots and made sure that those using chain saws wore approved NPS personal protection equipment. Despite the obvious safety hazards, no injuries were reported.

By late June, the cleanup was complete, although the park will wait until autumn to clear some of the larger trees in heavily wooded areas. During the 7-week effort, park staff dedicated 662 hours to the cleanup. An additional 112 hours were contributed by NPS personnel from the Midwest Archaeological Center in Lincoln and Great Lakes and Great Plains SSO personnel from Omaha. A total of 27 AmeriCorps volunteers contributed 211 hours and 100 community volunteers donated 461 hours of work. The Nebraska Job Service supplied five employees who had been displaced from their jobs when a local store was destroyed by the same storm that hit the park. Hired for 3 weeks using emergency funds remaining from 1993 floods, these workers contributed 500 hours of labor. In all, 160 people contributed 1,953 hours to the effort.

The need for immediate response to clear the debris prevented the park from taking advantage of some potential learning opportunities. The park had no staff or technical ability to map the debris pattern. They also have no ability to measure microscopic soil effects before or since the storm. Effects such as the impact to the microclimate caused by the destroyed trees may be measurable from Long-term Ecological Monitoring Program data; Homestead is a prototype park in the Prairie Parks Cluster for this program.

As the urban-wildland interface continues to expand, this type of incident can be expected to occur more often. Homestead will continue to assess its response plans for handling future natural disasters. Nevertheless, this was a situation when technology provided no ready solution to a messy and unpredictable resource problem. Cooperation, community partnerships, and hard work contributed to our achievements in confronting this situation.

Leopold Institute Endorses Recent Wilderness Publications

Former Sequoia and Kings Canyon National Park research scientist David Parsons points out several worthwhile recent publications from the Aldo Leopold Wilderness Research Institute:

Blahna, D., K. Smith, and J. Anderson. 1995. Backcountry llama packing: visitor perceptions of acceptability and conflict. Leisure Sciences **17(3)**:185-204.

Cole, D., A. Watson, and J. Roggenbuck. 1995. Trends in wilderness visitors and visits: Boundary Waters Canoe Area, Shining Rock, and Desolation Wildernesses. USDA Research Paper INT-RP-483.

Cole, D. 1996. Ecological manipulation in wilderness—an emerging management dilemma. International Journal of Wilderness **2(1)**:15-18. Cole, D., and P. Landres. 1996.

Cole, D. and Peter Landres. 1996. Threats to wilderness ecosystems: impacts and research needs. Ecological Applications **6(1)**:168-184.

Watson, A. 1995. An analysis of recent progress in recreation conflict research and perceptions of future challenges and opportunities. Leisure Sciences 17(3):235-238.

Located in Missoula, Montana, the Leopold Institute is an interagency program aimed at providing the information necessary to protect and manage wilderness resources and values. The National Park Service and National Biological Service are signatories to the interagency agreement providing support to the Institute. Parsons is now the institute director and can be contacted at (406) 542-4190; fax (406) 543-2663; e-mail "/s=d.parsons/ou1=s22l01a@mhs-fswa.attmail.com".

Ecosystem Approach to Forest Management

Professional natural resource managers and the public are increasingly interested in an ecosystem-based approach to forest management. This emerging interest raises the question of how such an approach might apply in a landscape that is dominated by nonindustrial private forest (NIPF) ownerships. Susan M. Campbell and D.B. Kittredge report on the results of a pilot study of a voluntary incentive-based program in one town in western Massachusetts in their 1996 article, Ecosystem-based Management on Multiple NIPF Ownerships. Carried in the Journal of Forestry 94(**2**)::24-29, their ideas may also be useful to parks as they work with their neighbors on similar issues.

Property Ownership and Habitat Fragmentation

The increased use of private market techniques to protect natural areas raises concern regarding how well these techniques implement nature reserve design concepts. Private market techniques work within the framework of property ownership. In their study, Legal Boundaries and Fragmentation of Georgia's (USA) Nature Reserves, Daryl R. Burkhard and D.H. Newman analyzed the impact that legal property ownership boundaries had on reserve fragmentation and, subsequently, on the potential for habitat fragmentation. The results of the study are reported in the Natural Areas Journal 16(**1**):24-35.

Groundwater Ecology Book

Groundwater Ecology (1994), a 571 page book from Academic Press of San Diego, CA, presents the status of knowledge about the ecosystems that occur in groundwater. Topics include the hydrodynamics and geomorphology of groundwater environments, the biota of aquifers and other groundwater systems, and anthropogenic stresses on groundwater ecosystems. Edited by J. Gibert, D.L. Danielopol, and J.A. Stanford, the book sells for $74.95.

Forest Fragmentation and Edge Effects on Birds

The early development of forest fragmentation effects on forest organisms is poorly understood, partly because most studies have been done in agricultural or suburban landscapes, long after the onset of fragmentation. John M. Hagen, W.M. Vander Haegen, and P.S. McKinley present a temporal model of forest fragmentation effects on densities of forest-breeding birds, with test data from an active industrial forest in a paper entitled, The Early Development of Forest Fragmentation Effects on Birds. Reported in Conservation Biology 10(**1**):188-202, the model and data indicate that, for reasons unrelated to traditional edge effects, retaining large tracts of forest can be important because they are relatively free from the variety of plant and animal population dynamics that take place near new edges, including the encroachment by *packing* of individuals displaced by habitat loss.

Monitoring, Natural Processes, and Wilderness

Most monitoring efforts of impacts on federally designated wilderness focus on specific conditions (such as vegetation, soil, water, fish, and wildlife), while the status of underlying natural processes that influence these conditions is largely overlooked. In his paper, Natural Processes: Wilderness Management Unrealized, Michael P. Murray uses four primary natural processes (trophism, gene flow, migration, and disturbance) to assess impacts derived from management within wilderness areas. Management recommendations are offered to provide a foundation for constructive debate on wilderness policy and management. Increased consideration of natural processes may enhance the ecological integrity of wilderness. The study can be found in the Natural Areas Journal 16(**1**):55-61.

Biology Encyclopedia Available

The *Encyclopedia of Environmental Biology* provides detailed information on issues that affect all resource managers and natural scientists. Edited by William A. Nierenberg, this 1995 work contains 150 articles that explore the impact of global change on plants, animals, and habitats and the causes and cures of environmental degradation. Written for researchers, professionals, and students in environmental science, law, city planning, and public policy, a few examples covered in the book include air pollution and forests, aquatic weeds, processes and loss of biodiversity, bird

communities, biogeochemistry, conservation programs for endangered plants, ecological restoration, equilibrium and nonequilibrium concepts in ecological models, forest insect control, forest canopies, keystone species, insect interactions with trees, packrat middens, population viability analysis, seed banks, and wetland ecology. Available in 3 volumes (2,114 pages), the encyclopedia is published by Academic Press of San Diego, CA, and costs $475.00.

Environmental Magazine Online

Science and the Environment is an online, bimonthly magazine specializing in providing world news summaries on a wide array of environmental issues. Published by Voyage Press, the magazine is designed for high school and university educators and students; it may also interest NPS interpreters who concentrate on natural resource issues interpretation.

The publication takes a multidisciplinary and nonpartisan approach to its coverage, which includes the latest scientific findings, developing government policies, and emerging technologies. The information is organized around eight chapters, including, biodiversity and wildlife health, population and agriculture, marine ecology, clean water, alternative energy and fuels, climate change and atmospheric studies, waste management and recycling, and clean air. Recent features have covered the congressional effort to relax federal wetlands regulations, preserving stopover sites for migratory birds, the spotted owl controversy and prosperity of local economies, and exotic species threats to native Hawaiian plants and animals.

The editors review over 500 magazines, specialized journals, and newspapers to produce each issue, which contains 80 of the most interesting and relevant news stories on important environmental topics. Each story cites the original source and lists contacts for future reference. The publication can be found on the World Wide Web at "http://www.cais.net/publish/voyage.htm#homeport."

Web Sites of Interest

Several World Wide Web sites relate to the natural resource management work of the National Park Service and may be of interest to readers with access to the web:

Aquatic (wetland) Plants
http://aquat1.ifas.ufl.edu/

Biodiversity and Biological Collections
http://muse.bio.cornell.edu/

Biodiversity, Ecology & the Environment
http://golgi.harvard.edu/biopages/biodiversity.html

Biodiversity & Ecosystems Network
http://straylight.tamu.edu/bene/bene.html

Biological Survey
http://www.nfrcg.gov

Botanists
http://meena.cc.uregina.ca/~liushus/bio/botany.html

Ecological Society of America
http://www.sdsc.edu/1/SDSC/Research/Comp_Bio/ESA/ESA.html

Ecology
http://biomserv.univ-lyon1.fr/Ecology-WWW.html

EcoWeb, University of Virginia
http://ecosys.drdr.virginia.edu:80/EcoWeb.html

Entomology
http://www.colostate.edu/Depts/Entomology/WWWVL-Entomology.html

Forestry
http://www.metla.fi/info/vlib/Forestry.html

Landscape Architecture
http://www.clr.toronto.edu/VIRTUALLIB/larch.html

National Biological Service
http://www.its.nbs.gov/nbs/

National Wildlife Refuge System
http://bluegoose.arw.r9.fws.gov/NWRSFiles/NWRSIndex.html

Natural Resources Research Info Pages
http://sfbox.vt.edu:10021/Y/yfleung/nrrips.html

Plant Biology
http://golgi.harvard.edu/biopages/botany.html

PLANTS Database, Natural Resources Conservation Service
http://trident.ftc.nrcs.usda.gov/npdc/

Remote Sensing and GIS
http://wwwrsl.forestry.umn.edu:10000/

Software, Biological
http://www.gdb.org/Dan/softsearch/softsearch.html.

Eastern Old-Growth Forests Examined

Old-growth forest–loosely described as forest that appears largely as it would have if Europeans had not settled North America–is of incalculable value. Old-growth sites can play a key role in plans for restoration of large areas of wilderness. Some, with restoration, could become core areas for future wildernesses, while others could become nodes of biodiversity linked by corridors. Scientists are just beginning to discover ways in which old-growth is biologically unique.

Eastern Old-Growth Forests: Prospects for Rediscovery and Recovery (ISBN 1-55963-408-1 [hardcover] and ISBN 1-55963-409-x [softcover]) is the first book devoted exclusively to old growth throughout the Eastern United States. Edited by Mary Byrd Davis, the book offers authoritative essays by leading experts and is divided into three main sections.

Biological and Cultural Values:
The ways in which old-growth forest differs biologically from second-growth forest, a topic that researchers are just beginning to understand, are explored, and the impact of old growth on the human psyche and the importance of old growth to the culture of Native Americans point to the cultural value of old growth.

Identificaiton:
Single ecosystems, including old-growth forests of southern New England, New York, and Pennsylvania, and of the Great Lakes, are considered.

Preservation and Restoration:
Examples of current preservation and restoration efforts are discussed and recommendations for further work are given.

These essays are framed by an introduction in which Robert Leverett analyzes historic views of forests and current definitions of old growth, and Davis explains the extent and location of Eastern old growth, and an epilogue in which Bill McKibben presents the remnants of original forest as a foreshadowing of the glory of the East's future forests.

Much remains to be learned about old-growth forest. This book will spur further efforts to identify, evaluate, preserve, and restore the forests that are its subject. It is available from Island Press (202) 234-7933.

MAMMOTH CAVE AREA BIOSPHERE RESERVE

Making a difference in groundwater protection

BY JEFF BRADYBAUGH

THE MAMMOTH CAVE AREA Biosphere Reserve (MCABR) was designated by the United Nations Educational, Scientific, and Cultural Organization (UNESCO) in 1990. It includes Mammoth Cave National Park and its primary groundwater recharge basins, an area totalling 44,700 hectares (110,453 acres). The park is the protected core area, and the basins outside the national park are designated the zone of cooperative use. Located in south-central Kentucky, the area is a karst landscape typified by numerous sinking streams and sinkholes, complex underground watercourses, and a multilayered cave system (longest in the world) with unique fauna and mineralization features. The karst landscape efficiently transports precipitation runoff (and any incorporated contaminants from surface land use) to subsurface streams, posing constant concern for area water quality degradation (fig. 1).

At the suggestion of the National Park Service and others, the Barren River Area Development District (BRADD) selected the UNESCO biosphere reserve model as the tool to address regional water quality issues. Chartered by the Commonwealth of Kentucky, BRADD is responsible for regional planning within the 10-county area surrounding Mammoth Cave National Park. With the biosphere reserve administered through BRADD, whose board of directors consists of locally elected officials, the biosphere program is viewed as a locally managed effort rather than a federal undertaking. As nearly all the land outside of the park is in private ownership, this organizational structure has proven critical to initiating and carrying out biosphere reserve programs.

The Barren River Area Development District established a biosphere reserve council to coordinate resource management activities. The council is comprised of technical specialists from: Western Kentucky University, USDA (U.S. Department of Agriculture) Forest Service, USDA Combined Farm Services Agency, USDA Natural Resources Conservation Service, Tennessee Valley Authority, U.S. Economic Development Administration, U.S. Army Corps of Engineers, agencies of the Kentucky natural resources cabinet, the Resources Conservation and Development District, the Caveland Sanitation Authority, and the National Park Service.

IMPLEMENTATION OF THE BIOSPHERE RESERVE PROGRAM

Several noteworthy programs and projects have been initiated or enhanced through the collective efforts of the governments and agencies cooperating under the Mammoth Cave Area Biosphere Reserve umbrella.

MAMMOTH CAVE AREA WATER QUALITY PROJECT

To protect the Mammoth Cave watershed, a partnership was established with farmers, universities, and agencies to protect aquatic resources by promoting sustainable agriculture and on-the-farm *best management practices* (BMPs). Since 1990, the USDA has made available $950,000 on a cost-sharing basis with local farmers for the design and installation of animal waste BMPs for feedlots and dairies. Agencies, including the National Park Service, have invested $330,000 in groundwater and aquatic community monitoring to assess the effectiveness of BMPs. An Environmental Protection Agency grant has been secured to continue this project over the next four years.

REGIONAL GIS/GPS AND DEVELOPMENT OF A GEOSPATIAL DATA CENTER

Members of the biosphere reserve council have pooled their resources to enhance data sharing and data analysis capabilities. A GIS (Geographic Information System) was established at BRADD to supplement and interact with partner systems. Agencies contributed to purchase a GPS (global positioning satellite) base station that has been used in developing groundwater hazard maps where interstate highways and railroads cross the groundwater basins (fig. 1). The series of maps allows emergency responders to identify sites where hazardous spills from road or rail accidents could enter sinks or otherwise be injected into the aquifer, and allows them to quickly formulate a containment strategy. With support from the Mammoth Cave Area Biosphere Reserve and park assistance via the NPS Lower Mississippi Delta Initiative, the GPS system is being used to map features of a local civil war battlefield, assisting community efforts for its protection. Through a grant from the U.S. Geological Survey (USGS), the biosphere reserve has established a geospatial data center at Western Kentucky University, as a node of the nationwide USGS system.

ECONOMIC DEVELOPMENT AND IMPACT STUDIES

The Economic Development Administration funded a MCABR study to assess the potential for compatible industrial development along Interstate 65 within the reserve. Existing and potential environmental risks and identification of suitable and unsuitable development locations were analyzed. Through the Barren River Area Development District, this information has been made available to the affected communities to assist in economic and infrastructure planning.

The National Biological Service, Michigan State University, and Southern Illinois University are nearing completion of a visitor use and economic impact study for the park and local area. Data will be used to assess the impact of tourism expenditures locally and to formulate regional plans for sustainable tourism currently under development by the West Kentucky Corporation.

Environmental Education

Plans for a nonprofit institute, as part of the biosphere reserve, are being developed to extend and enhance the education and research programs available to local residents and resource managers, including environmental and cultural resource management, sustainability, and heritage appreciation.

To keep the public informed of ongoing water resource management efforts in the biosphere reserve, an educational video was produced through Kentucky Educational Television. It describes the broad concerns of stakeholders, how consensus planning was used to focus on common goals, and the actions taken to enhance water quality. The video emphasizes the progress made through cooperation between businesses, landowners, and agencies working within the reserve.

Mammoth Cave Resources Conservation and Development Area

With the intense focus on water quality in the karst aquifer and the need to remedy related agricultural impacts, agency managers and local officials petitioned the Secretary of Agriculture to designate an area in south-central Kentucky including the biosphere reserve as a resources conservation and development area (RC&D). Established in 1991 and represented on the biosphere council, the RC&D uses its resources to meet goals common to both programs. The RC&D receives USDA funding each year, available for matching grants, to accomplish projects relating to solid waste management, non-point source pollution control, conservation education, and rural infrastructure. While most projects are relatively small in size, they provide rural communities with opportunities to address longstanding problems and to become participants in regional conservation efforts.

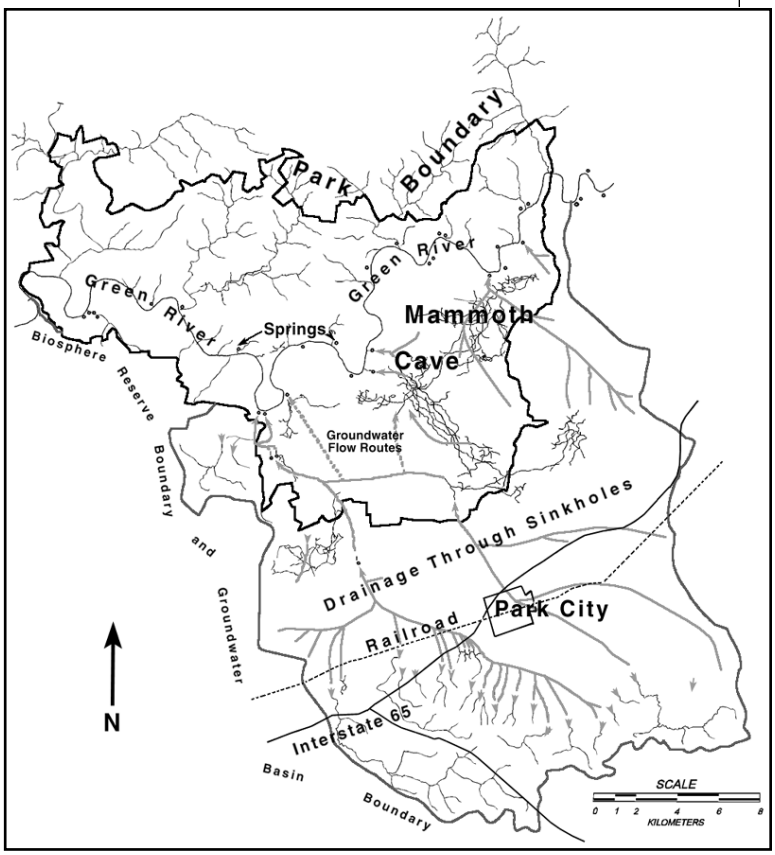

Figure 1. The Mammoth Cave Area Biosphere Reserve (gray boundary line—before the recent expansion) encompasses Mammoth Cave National Park (black boundary line) and most of the Groundwater Basin, the primary groundwater recharge area for the cave. The thick gray lines terminating in arrows indicate the flow of precipitation runoff (and contaminants) through neighboring towns and across highways enroute to the cave. The recently expanded biosphere reserve increases opportunities to promote a water quality program throughout the Groundwater Basin that will help protect cave resources.

What the Future Holds

The Mammoth Cave Area Biosphere Reserve, with the national park as the core area, has brought national attention to local conservation issues, including additional financial resources not available previously. Landowners and communities have derived tangible benefits and received recognition for working together to protect resource values. The park benefits in that external resource threats and issues are being addressed and a forum exists to discuss long-term resource protection policies with local officials.

In August, the USMAB National Committee approved expanding the biosphere reserve to 368,000 hectares (909,328 acres). Within the expanded reserve, an opportunity exists to develop greater involvement of rural and small-town residents, to work with commercial natural resource users, and to partner with people interested in conservation of historic resources and the cultural traditions of the region. These opportunities reflect the continuing growth of the biosphere reserve program. In addition to providing a larger land area, the expanded biosphere reserve also continues the focus on areas of critical environmental concern–especially the Mammoth Cave groundwater basins.

Jeff Bradybaugh is Chief, Science and Resources Management Division at Mammoth Cave National Park, Kentucky. Contact him at Mammoth Cave National Park; Mammoth Cave; KY 42259; (502) 758-2251.

Figure 1. Located in southeastern Utah, Capitol Reef National Park nicely frames the Waterpocket Fold, a ridge that runs nearly the entire length of the park. The study took place in the southern end of the park in drainages that cut laterally across the feature.

Figure 2 (left). The Waterpocket Fold viewed from the east. Drainages that contain the rock pools cut across the fold down the gently sloping eastern side.

An Intensive Study of Desert Rock Pool Systems in Capitol Reef National Park

By Toben Lafrancois

Although located in one of the most arid regions of the Colorado Plateau, Capitol Reef National Park, Utah, contains very unusual aquatic systems. The park is located in Wayne and Garfield counties of South-Central Utah, 40 km (64 mi) west of Hanksville on highway U.S. 24 (fig. 1). The 125,000-ha (308,750 acre) park encompasses the Waterpocket Fold, a 62.5-km long by 1.25-km wide (100 mi x 2 mi) ridge of Navajo sandstone. The Water–pocket Fold contains many drainages cut laterally across its width due to water erosion (fig. 2). Within these drainages are rock pools, which form in series down the drainages (fig. 3). These rock pools are also called *tinajas,* which translates from Spanish as "water jug or tank." As a result of the specific geomorphology of the Waterpocket Fold, these rock pool systems are the best developed in the region (Spence et al. 1993). The Waterpocket Fold contains 80 major drainages including 460 tinajas (Berghoff 1994).

Rock pools in arid systems have received scant attention in the scientific literature, yet they may be the most susceptible of all aquatic habitats to human influences (Dodson 1988). Desert rock pools of the American Southwest are important ecological systems due both to their relative scarcity and their critical functions. Rock pools retain water in otherwise arid systems and are of focal importance to terrestrial wildlife; they also support unique plant communities (Dodson 1988; Spence and Henderson 1993; Van Haverbeke 1990) and are important for use in monitoring ecosystem health. Aquatic macroinvertebrates, which are the major component of Capitol Reef rock pool communities, are often excellent indicator organisms. They are important for monitoring such factors as water quality, anthropogenic disturbances, and other changes that affect the surrounding terrestrial system.

In the park, tinajas range from small, ephemeral pools to larger, permanent pools. Some have accumulated enough sediment to support wetland plant species (fig. 4) including cattails (*Typha* sp.), wetland grasses (*Phragmites* sp.), and black willow (*Salix nigra*). Against the backdrop of one of the most arid regions of the Colorado Plateau, the presence of small wetlands offers a startling contrast.

The Study

The chemistry, biology, and ecology of the Capitol Reef rock pools were studied by Dr. Jill Baron (National Biological Service), Dr. Boris Kondratieff (Colorado State University), and Toben Lafrancois (graduate student, Colorado State University). We gave special attention to the responses of these systems to disturbance. Park resource managers required baseline biological and chemical data on the rock pools for use when making policy and management decisions and when designing educational programs about the park.

We began the study in September 1993 and continued field work until the following September, concentrating on 20 rock pools in five different drainages along the Waterpocket Fold. We sampled the pools on a weekly basis from May to late August 1994. Although intensive, the sampling was nondestructive. We collected macroinvertebrates and anurans (members of an amphibian order that includes

frogs and toads) using a 1 mm^2 mesh standard D-net, field identified to the lowest possible taxonomic level, and ranked according to abundance categories. Physical and water chemistry data gathered at each pool included volume, temperature, pH, conductivity, and major ions. We also collected rainfall amount from two rain meters in each study drainage on a weekly basis. Chemical data from this project have also been analyzed.

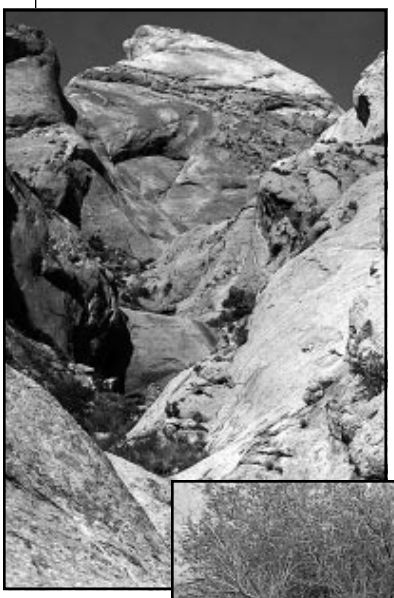

Figure 3. Rock pools, or tinajas, *form in a series down the drainages of the water-pocket fold.*

Figure 4. Some tinajas collect enough sediment to support wetland plant species such as cattail.

Rock Pool Fauna

Several different groups of aquatic animal species common to the Colorado Plateau can be found in the park rock pools. Of these, most have a highly vagile (free-moving) adult stage, capable of dispersal over large areas. A large number (62) of macroinvertebrate and anuran species occur in the rock pools, about twice what has been reported from other rock pool studies in this area.

Aquatic insects are a major component of the rock pool communities. All typical groups of *lentic* (standing water) insects are found here, often represented by common and geographically widespread species. The northern case-making caddisfly (*Limnephilus taloga*), the small minnow mayfly (*Callibaetis pictus*), and many common dragonfly species were abundant in the rock pools. Aquatic beetles were particularly diverse and abundant. Water beetles commonly found ranged from the minute predaceous diving beetle *(Liodessus affinus)* to the gigantic water scavenger beetle (*Hydrophilus triangularis*). Water bugs such as water boatmen (*Graptocorixa abdominalis*), giant water bugs (*Lethocerus americanus*), water striders (*Aquarius remigis*), and backswimmers (*Notonecta kirbyi*) also can be seen in the rock pools, along with mosquito (*Culex tarsalis*) and chironomid midge larvae (*Phaenopsectra dyari*). These examples represent some of the major groups of aquatic insects in the rock pools, but only a small fraction of the 62 inhabitants recorded to date.

Vertebrates in these pools are represented by frogs and toads, such as the canyon tree frog (*Hila arenicolor*) and the spadefoot toad (*Scaphiopus intermontanus*). Some crustaceans found in the rock pools were fairy shrimp (*Streptocephalus texanus*) and tadpole shrimp (*Triops longicaudatus*). These crustaceans are well-adapted to aquatic life in arid regions.

The animals that compose these rock pool communities are common, hardy organisms that are well dispersed across the Colorado Plateau. Many adult beetles and waterbugs are capable of flight, while other groups such as the crustaceans and spadefoot toads are physiologically adapted to unstable habitats. These characteristics of the rock pool communities suggest that they would recover rapidly from such natural disturbances as floods or drought. During the summer of 1994, floods that occurred due to cloudburst storms did not significantly affect the rock pool communities. Furthermore, we observed no major difference between a rock pool community before a pool dried up and the community that appeared when the same pool was refilled by rain. Rock pools that are components of wetlands, however, support a greater number of species than other rock pools (Lafrancois 1995) and can be expected to act as refugia from natural disturbances. The effects of human disturbances on these systems remain unknown.

Benefits of Monitoring

Several advantages accompany intensive (weekly) sampling of aquatic resources. The number of rock pool species found in this study is over twice the previous park record. The relatively high number of sampling periods provided opportunity to statistically analyze aspects of the rock pools (such as presence or absence of surrounding wetlands) that affect the biological community. Understanding the natural variation of a community, which also requires frequent sampling of the system, is important when developing a data set that will be used as a baseline for a monitoring program. This research provided resource managers with necessary baseline information concerning uncommon and unknown systems. Data regarding the basic biology and ecology of the rock pools are necessary for future ecosystem monitoring and current management and education programs.

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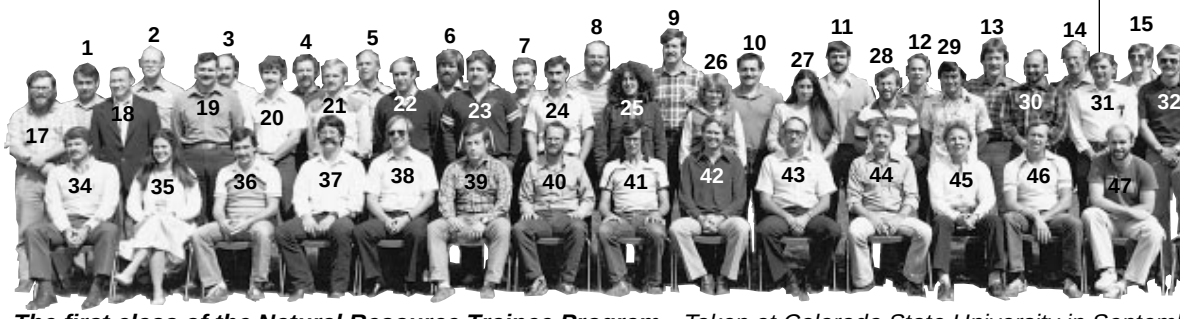
Where are they now?

Results of a recent informal survey of participants from the first Natural Resource Trainee Program indicate that they have gone on to flourish in natural resource management careers, many of them becoming leaders in their field. Nearly 90% of the first 36 trainees completed the course. Only four did not graduate, and of those, two still work for the National Park Service in resource management related positions. Six are either superintendents or assistant superintendents (one has retired), while ten have become chiefs of resource management. Ten have remained in various resource management positions other than division chief; six have not moved from their original park, deepening their understanding of the resources and their respective ecosystems. Three are system support office natural resource program leaders and two now conduct biological research in parks for the National Biological Service. One became a district park ranger and has put his prescribed fire background from the course to good use. Two retired and two have died. Of three who left government service, one is pursuing a Ph.D. in wildlife biology.

Course participants generally laud the value of the trainee program from both a personal and professional perspective. The program rallied support for the professionalization of natural resource management, provided funding for career development, and gave employees the time necessary to get in-depth, specialized training. Trainees stepped into resource management positions, often as newcomers in parks that formerly had no such expertise, and were given time to develop in this challenging role. Other parks saw the course as an opportunity to improve the level of training of their resource managers without bearing the costs themselves. All trainees developed a rich collection of contacts with subject matter experts. Bruce Rodgers, Chief of Resource Management for the southeast Utah group (Canyonlands, Arches, Natural Bridges) points out that "in those days, few people had a clear idea of what a resource management specialist was supposed to do. This program helped define... those jobs, both for the trainees and for the [National Park] Service." North Cascades National Park Chief of Resource Management Bruce Freet believes the program formed the basis for "a highly visible, fairly rapid... emphasis on science-based resource management."

Some participants immediately translated training skills into park projects, such as developing an air quality monitoring program for Rocky Mountain National Park or feral animal removal at Haleakala National Park. However, most cite the breadth of the training approach as its main appeal and the source of its success. Participants visited numerous parks and studied resource problems to help them develop the tools needed to deal with diverse issues in the field. "We are not specialists as our titles suggest," one trainee offered, "but daily have to deal with issues that other agencies might have four or five people [to handle]." Natural Bridges National Monument Superintendent Steve Chaney recognized that the course "was not so much a program to teach technical skills as it was a program to teach concepts, instill values, and provide management tools." At the end of the 2-year course, a trainee had developed the broad scope of skills to establish a resource management program in the field.

A further benefit came with the contacts developed between participants and university and private sector experts. Denali National Park and Preserve Chief of Resource Management Gordon Olson indicated that this was one of the most important aspects of the training. "I... designed most elements of my program. This gave me an opportunity to seek training from many sources and to participate in fact-finding trips in various parts of the country. These circumstances allowed me to better appreciate policies and programs of other agencies and to establish a broad network of professionals. In today's climate of partnerships, this knowledge has become extremely important and useful in developing professional relationships."



The first class of the Natural Resource Trainee Program—*Taken at Colorado State University in Septem at the beginning of their 2-year training stint, this photograph appeared on the cover of* Park Science *(volume number 2) and accompanied an article describing this exciting new natural resource training opportunity. The the trainees assembled was for their graduation at Mather Training Center in August, 1994.*

A Transforming Act

In addition to developing a more broadly trained and networked natural resource workforce, the program also institutionalized resource management in the parks, elevating it to the level of other operational divisions. Rodgers explains, "the trainee program played the single most important role in establishing resource management as a major discipline in park management. It sent forth trained, educated disciples to articulate the need for integrating natural resource considerations with all other management activities. By the early 1990s... dozens of program graduates [were located] in parks and central offices [and were] able to develop and sustain support for resource management budget initiatives and campaign for... separating resource management from ranger activities at the operational level."

Resource management has clearly become better integrated into park management considerations since 1982. Channel Islands National Park Ecologist Linda Dye sees this happening in her park and in general. "We are operating from a base of

Continued on page 18

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Table 1. Then and Now—The First Natural Resource Trainees (1982)

Back Row (standing, left to right):	Then	Now
1 Harold Werner	Trainee prototype, Southwest Regional Office	Sequoia-Kings Canyon National Park
2 Ben Holmes	Coordinator, Midwest Regional Office	Fire Management Officer, Great Lakes and Great Plains System Support Offices (SSO)
3 Steve Smith	Coordinator, Southeast Regional Office	Fire Management Officer, Atlantic Coast SSO
4 John Lissoway	(First natural resource trainee—completed course at Bandelier National Monument as pilot program for what became the Natural Resource Trainee Program)	Area Fire Management Officer, Bandelier and El Malpais National Monuments
5 Mike Maule	Coordinator, Mid-Atlantic Regional Office	Retired in Santa Fe, NM
6 Steve DeBenedetti	Trainee, Sequoia-Kings Canyon National Park	Deceased
7 Dick Prasil	Coordinator, Pacific Northwest Regional Office	Retired
8 Gordon Olson	Trainee, Antietam National Battlefield	Chief, Division of Research and Resource Preservation, Denali National Park and Preserve
9 Keith Langdon	Trainee, Catoctin Mountain Park	Plant ecologist, Great Smoky Mountains National Park
10 Larry Belli	Trainee, Glen Canyon National Recreation Area	Assistant Superintendent, Everglades National Park
11 John Townsend	Trainee, Indiana Dunes National Lakeshore	Position in ranger activities, Midwest Field Area
12 Bruce Freet	Trainee, Big Cypress National Preserve	Chief of Resource Management, North Cascades National Park
13 Mike Duwe	Trainee, Big South Fork National River and Recreation Area	Environmental Protection Specialist, Sleeping Bear Dunes National Lakeshore
14 Dave Haskell	Trainee, Shenandoah National Park	Director, Grand Canyon Science Center, Grand Canyon National Park
15 Lillian Rummel	Trainee, National Capital Parks-East	Deceased
16 Linda Dye	Trainee, Biscayne National Park	Ecologist-Database Administrator, Channel Islands National Park
Middle Row (left to right):		
17 Ed Schreiner	Trainee, Olympic National Park	Research Biologist, National Biological Service, Forest and Range Ecosystem Science Center, Corvallis, Oregon—Duty Station, Olympic National Park Field Station
18 Hank McCutcheon	Audited courses while at Rocky Mountain National Park	With NBS at Northern Arizona University (?)
19 Steve Budd-Jack	Trainee, Mesa Verde National Park	District Ranger, Mesa Verde
20 Steve Chaney	Trainee, Buffalo National River	Superintendent, Natural Bridges National Monument
21 Ken Stephens	Audited courses while at Bandelier National Monument	Supervisory Resource Specialist, New River Gorge National River
22 Bruce Rodgers	Trainee, Assateague Island National Seashore	Chief of Resource Management, southeast Utah group (Canyonlands, Arches, Natural Bridges)
23 Bob King	Trainee, Padre Island National Seashore	Left NPS, possibly to the Environmental Protection Agency
24 Dave Reynolds	Trainee, New River Gorge National River	Natural Resource Program Leader, Chesapeake-Allegheny SSO
25 Kathy Jope	Trainee, Katmai National Park	Natural Resource Program Leader, Columbia-Cascades SSO
26 Chris Baumann	Trainee, Chesapeake &Ohio Canal National Historical Park	Working on Ph.D. in wildlife biology at the University of Massachusetts
27 Barbara Samora	Trainee, Cape Cod National Seashore	Mount Rainier National Park
28 Jeff Bradybaugh	Trainee, Theodore Roosevelt National Park	Chief of Resource Management, Mammoth Cave National Park
29 Ron Nagata	Trainee, Haleakala National Park	Chief of Resource Management, Haleakala National Park
30 Frank Buono	Trainee, Chaco Culture National Historical Park	Assistant Superintendent for Natural Resources, Mohave National Preserve
31 Len Frank	Coordinator, North Atlantic Regional Office	Retired (possibly in Coral Gables, FL)
32 Steve Cinnamon	Trainee, Wupatki National Monument	Natural Resource Program Leader, Great Plains SSO
33 Gary Ahlstrand	Coordinator, Alaska Regional Office	Chief of Resource Management, Mount Rainier National Park
Bottom Row (sitting, left to right):		
34 Bill Ehorn	Audited courses, Channel Islands National Park	Retired as Superintendent of Redwood National Park
35 Debbie Buzzell	Trainee, Morristown National Historical Park	Left government service
36 Norm Fletcher	Trainee, Acadia National Park	Left government service
37 Brad Cella	Trainee, Wrangell-St. Elias National Park and Preserve	Fire Management Officer, Alaska SSO
38 Garee Williamson	Trainee, Cuyahoga Valley National Recreation Area	Cuyahoga Valley National Recreation Area
39 Walter Loope	Trainee, Pictured Rocks National Lakeshore	Pictured Rocks (NBS field station) National Lakeshore
40 Tim Tunison	Trainee, Hawaii Volcanoes National Park	Resource Management Specialist, Hawaii Volcanoes
41 Jack Gulvin	Trainee, Yellowstone National Park	Retired from Cuyahoga Valley NRA (?)
42 Stan Lock	Coordinator, National Capital Regional Office	National Capital SSO (White House Liaison)
43 Ro Wauer	Trainee Program Founder and Manager, Washington Office	Retired in Victoria, Texas—writing bird finding guides to the national parks and other natural history publications
44 Jon Jarvis	Trainee, Crater Lake National Park	Superintendent, Wrangell-St. Elias National Park and Preserve
45 John Miller	Trainee, Grand Canyon National Park	Chief of Resource Management, Padre Island National Seashore
46 Jeff Connor	Trainee, Canyonlands National Park	Resource Management Specialist, Rocky Mountain National Park
47 Allan O'Connell	Trainee, Fire Island National Seashore	Research Wildlife Biologist and NBS Cooperative Park Studies Unit Leader, University of Maine
48 Joanne Michalovic	Trainee, Mount Rainier National Park	Superintendent, Women's Rights National Historical Park
Not Shown		
Elizabeth Johnson	Trainee, Delaware Water Gap National Recreation Area	Chief of Resource Management, Delaware Water Gap
Cat Hoffman-Hawkins	Supplementary trainee from Mount Rainier—February, 1994. Graduated with 2nd trainee class	Chief of Resource Management, Olympic National Park

more knowledge than in the past. [We have] input into NPS natural resource management decisions. Attitudes are changing and the need to operate from an informed place is being validated."

In many cases, the trainees themselves have risen to positions of influence and should be able to help continue the integration process into the future. "In a very practical sense," says Bruce Freet, North Cascades National Park Chief of Resource Management, "[we] would not have the [positions] and monies... allocated for natural and cultural resource management that we have today [if it were not for the trainee program]. Our class and others that followed... had an effect on NPS priorities over time. Now, many of us... are in influential management positions, so the effects on the agency could be even greater during the next decade."

Not all changes occurred in parks, however. The training program also launched the National Park Service into new areas of expertise as Frank Buono, now Assistant Superintendent of Joshua Tree National Park, points outs. He views the course as having "provided a basis for developing experience in complex legal and regulatory areas–air, water, minerals, rights of way–that was previously missing." These national programs continue to serve parks well primarily from the newly established Natural Resource Program Center in Colorado.

Over the course of six classes from 1982-1993, the trainee program placed over 140 resource professionals in the parks and helped the National Park Service take a big step forward toward resource management professionalization. The highest percentage of graduates[1] have become resource management specialists (29%), followed by natural resource specialists (17%), park rangers or supervisory park rangers (13%), and supervisory natural resource specialists (5%). Other graduates are biologists; biological, physical science, and GIS cartographic technicians; fire management officers; and environmental protection specialists, etc. Three (as of 1992) are superintendents. According to Bill Walker, Wauer's successor as trainee program manager for courses 2-6, "we continue to see all course participants making strong contributions to the resource management profession. Graduates from even the most recent courses now serve in chief of resource management and superintendent positions, and more and more of them will move up as the 1990s come to a close."

While under way, the trainee program evolved considerably, originally concentrating on just the individual needs of participants. By the mid-1980s, the program changed to combine both park-tailored courses with a core set of academic courses in an effort to make the training more even for all participants. In the end, the program had succeeded in placing the first professional resource managers in many natural resource parks, but it could not be expected to train all NPS resource managers. Subsequently, the emphasis on training in the technical aspects of resource management (e.g., biology, fisheries, wildlife management) shifted. The Vail Agenda and the Strategic Plan for Natural Resource Management, both published earlier this decade, recommended that the National Park Service concentrate on recruiting academically trained resource managers with appropriate degrees and training them in the National Park Service approach to resource management (e.g., compliance, practical aspects of resource management planning, etc.).

What's Next?

The revitalized Albright Employee Development Center is already offering training that shares the NPS-specific approaches to resource management not taught in an academic setting. Designed to cover both fundamentals and advanced topics, these courses will build on the most successful components developed during the Natural Resource Trainee Program.

The natural resource management training manager at Albright, Dennis Vásquez, recently coordinated the ambitious 6-week course, "Fundamentals for Professional Natural Resource Managers." This training focused on developing competence in the areas of NPS resource stewardship, planning and compliance, professional credibility, communications, project and program development, and other areas. Offered last May and June, the course was funded from a central account and was attended by more than 20 park resource managers with an average of 2½ years of NPS employment. Albright will also serve as a natural resource training clearinghouse, facilitating NPS participation in training and professionalization opportunities offered through university short courses and other non-NPS means.

While training is important, Delaware Water Gap National Recreation Area Chief of Resource Management Beth Johnson points out that "we need to be able to attract previously trained, highly skilled scientists to advance our resource management programs. They must complete the inventories that are so much needed, [and] they must design and implement monitoring programs and analyze the data that is produced to meet the agreed upon management objectives for the park unit."

Some of her concerns are addressed in the long-range resource management professionalization thrust that gained focus through the Strategic Plan for Natural Resource Management, the Vail Agenda natural resource careers committee, and the Ad Hoc Report. Now a *stewardship* professionalization plan that includes both cultural and natural resources is in final review and is expected to be released later this year; this document stresses an integrated approach to professionalization as the key to taking resource management to the next tier. Important parts of the professionalization movement include continuing to establish positions with positive degree requirements, carefully recruiting academically trained specialists, retraining NPS staff, encouraging career paths that can lead to superintendencies, and developing natural resource competencies. Also important are enhancing and developing new partnerships, improving our relationships with the National Biological Service and universities, pursuing NR-MAP staffing level recommendations through a separate initiative, and keeping attention focused on Director Kennedy's support of the "Stewardship Today for Parks Tomorrow" initiative to double resource management staff by the year 2000. All are exciting potentialities, but restructuring, reengineering, and diminishing budgets have all made professionalization goals more difficult to reach. However, when the time is right, we are ready to move forward.

[1] Percentages pertain to 108 graduates from the first five courses as of October 1992.

Figure 2 (left) and figure 3 (above). Home to coastal sand dunes, bluffs, forests, lakes, and streams, the park began a comprehensive aquatic resource inventory and monitoring program in 1990. Survey sites include Deer, Bass, and Otter Lakes (left), and middle Otter Creek (above).

Maintaining a Water Quality Monitoring Program at Sleeping Bear Dunes

By Laurel L. Last and Richard L. Whitman

Sleeping Bear Dunes National Lakeshore is located on the northwest shore of the Michigan lower peninsula (fig. 1). The park is a diverse landscape of coastal sand dunes, bluffs, forests, lakes, and streams (figs. 2 and 3). Its topography and geology have been influenced by glaciation, erosion, and sedimentation. Although extensive lumbering begun in the late 1800s had depleted the area's forest resources by 1910, much of the cleared land has been reforested since the 1920s. Presently, much of the national lakeshore is covered by pine, aspen, and northern hardwoods. Over the years, tourism has become the number one industry for the local economy. Concern for protection of area natural resources led to park creation in 1970. The lakeshore now provides thousands of visitors each year with a variety of recreational opportunities, from enjoying the outdoors (through hiking, canoeing, fishing, beachcombing, and other activities) to exploring the fascinating history.

Program Beginnings

In accordance with the lakeshore general management plan (NPS 1979), the park initiated a project in 1990 to provide a comprehensive aquatic natural resource inventory and a program for long-term aquatic resource monitoring. During the first 3 years of the program, 1990-92, the NPS Water Resources Division performed a thorough, well-funded aquatic resource inventory. The result was both a report and a manual to guide future lakeshore monitoring efforts (Boyle and Hoefs 1993b and 1993a).

Following the initial 3-year project period, the monitoring program became the responsibility of the park. In 1993, a bachelor-level biologist without specific aquatic training and unfamiliar with the project continued the monitoring program. She collected the data and samples, with help from various other park employees and volunteers, and the samples were analyzed by an outside lab and expert macroinvertebrate specialist. The park received only the data sheets and lab results, with no interpretation or analysis.

Figure 1 (map). Sleeping Bear Dunes National Lakeshore, Michigan.

In 1994, the first author, working for the NBS Lake Michigan Ecological Station, sampled and collected field data (with help from the second author and two park interns); she also analyzed and interpreted macroinvertebrate and water

Continued on page 20

quality data. An aquatic ecologist working on her master's degree conducted the monitoring after she received 3 weeks of training at the ecological station. She completed the macroinvertebrate analysis that fall and winter while attending the university. The station performed the water quality analysis using methodology outlined in Whitman et al. (1992) and provided the park with a report (Whitman et al. 1994).

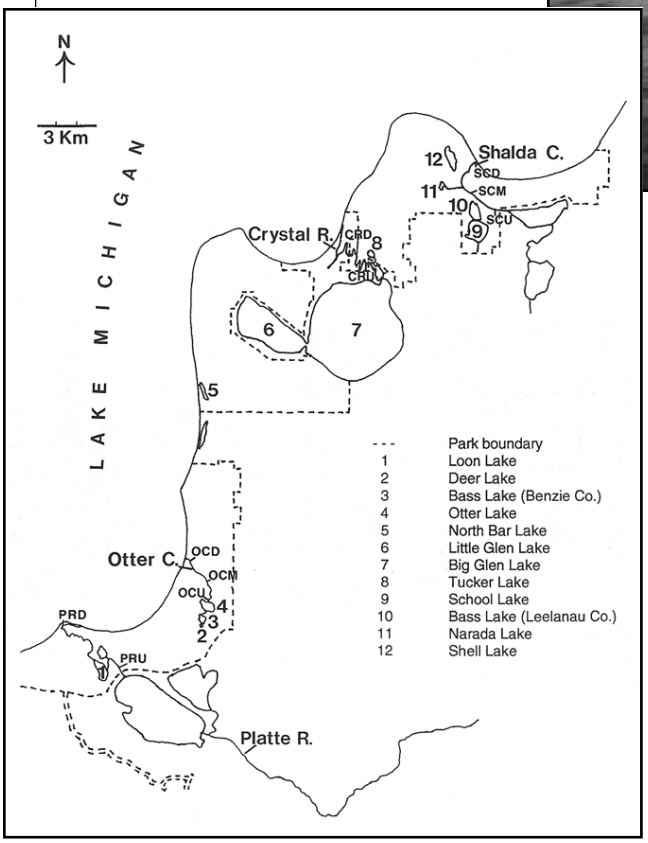

Figure 4. Map of Sleeping Bear Dunes National Lakeshore, Michigan, and the 12 lakes and 10 stream sites under study in 1994 and 1995. (North and South Manitou Islands not shown).

In 1995, we returned with a fisheries biologist and five volunteers and finished the sampling in only 2 days, versus several weeks of effort in 1994. The National Biological Service again analyzed water quality, but had inadequate human resources for the macroinvertebrate analysis.

This article presents an overview of the 1990-95 studies of the Sleeping Bear Dunes monitoring program. It compares logistical approaches used in different years of the program, analyzes problems in maintaining program consistency, and suggests solutions to these problems.

Figure 5. The first author performed Secchi disc visibility depth determinations on Big Glen Lake in the 1994 studies.

Consistency Issues

Data collection methods were generally similar between years (Boyle and Hoefs 1993a and 1993b, Whitman et al. 1994). Staff monitored 21 lakes in 1990. Although 12 lakes were monitored each year thereafter, only 10 remained in common between 1991-92 and 1993-95. The lakes sampled in 1994-95 are shown in figure 4. Lake data collected all years included temperature and dissolved oxygen vertical profiles; Secchi disk transparency (fig. 5); and surface (or "shallow") pH, chlorophyll *a*, nitrate-nitrogen, and total phosphorus. Additional characteristics monitored in 1994-95 included specific conductance (an indicator of ion content) and ammonia-nitrogen. Except for 1993, 10 sites on four streams–Platte River, Otter Creek, Crystal River, and Shalda Creek–were monitored every year (see figure 4 for site locations). Stream data collected included temperature, dissolved oxygen concentration, pH, and benthic macroinvertebrate community composition all years, plus specific conductance in 1994-95. Five benthic macroinvertebrate samples were collected at each stream site using a square-foot (1.0 mm mesh) Surber sampler.

Besides the designed reduction in collected data after the initial 3-year inventory, other differences in methods resulted from personnel, time, and budget decreases and loss of corporate memory. Fewer stream sites were sampled in 1993, and some of the 1994-95 sites were not the same ones sampled during the inventory. The lake samples were analyzed for ammonia-nitrogen in 1994-95, rather than Kjeldahl as in 1990-92, and no nitrogen species were analyzed in 1993. Nutrients and chlorophyll *a* analyses were done for shallow and deep samples from most lakes during the 1990-92 inventory. In 1993, samples were taken as depth composites as outlined by Boyle and Hoefs (1993a). Although depth-composited samples were taken initially in 1994, time constraints soon forced surface grab sampling instead.

One very important difference between years was the length of the data collection period. Although stream macroinvertebrate communities do not usually vary much over the short-term, some lake water parameters can change dramatically from day to day, depending on ambient events, changes in biological systems, and other limnological occurrences. Accurate comparisons of chlorophyll *a* or nutrient concentrations between lakes can therefore only be made if the observations occur within a 1- or 2-day period of comparable

weather. Lake sampling occurred over a 12-, a 4-, and a 5-day period in 1990, 1991, and 1992, respectively. Lake sampling in 1993 occurred over a 51-day period. Although the rest of the lake sampling took 15 days in 1994, samples for (surface) nutrient and chlorophyll *a* analyses were taken within an 8- and a 24-hour period, respectively. In 1995, all of the lakes were sampled in 1 day (12 hours).

Inconsistency in sampling methods restricts an investigator's ability to determine if data changes reflect actual water quality trends, thereby limiting the utility of a monitoring program. However, if methods are carefully recorded, one can determine how comparable the resulting data are. In this monitoring program, some data collection methods (such as exact sampling locations) were not well documented, making replication difficult. However, most methods were well documented. We know, for example, at what depths chlorophyll *a* samples were taken in each lake in each year, and, although the resulting concentrations may not correspond directly, we can still make general comparisons. Although methods consistency is very important, methods documentation is critical.

Although methods consistency is very important, methods documentation is critical.

Lessons Learned

The water quality monitoring program has provided us with valuable insight into the problems, issues, and compromises inherent in the creation and operation of such a program in a world of finite resources. From both our personal experiences in 1994-95 and a study of the project from its initiation, we have learned some lessons that we believe will be useful to those involved with monitoring programs in other parks.

Although mission commitment by the host park and regional office remained impressively strong, many of the problems encountered were related to lack of continuity of personnel and support and the learning curve to be expected for any complex field project. Consistent, reliable commitment and support are imperative not only for program continuity, but also for data integrity and ultimate program survival. Due to fiscal constraints, program scale may be compromised for the sake of program survival, but consistency and continuity of salient programmatic elements must be maintained on some routine basis. Lack of adequate programmatic resources translates to increased turnover in program personnel and experience, resulting in decreased performance, efficiency, analytical accuracy, and consistency, and–most importantly–loss of corporate memory.

There are many programmatic compromises and issues involved in the development and operation of any water quality monitoring program, such as fineness or coarseness of sampling intensity, replication, quality assurance, and spacial-temporal representation. While the former issues are quite important, consistency and program intensity remain the foundation of a quality monitoring program. Nonetheless, modifications to improve accuracy, efficiency, representation, and techniques should be continually considered. While it is possible to maintain program size by decreasing monitoring frequency (e.g., sampling in alternate years), loss of experienced personnel between sampling years remains a critical disadvantage. Also, gaps in information grow with decreased monitoring activity, and the advantages and disadvantages should be weighed in each situation.

Sleeping Bear Dunes and the former NPS Midwest Regional Office management remain deeply committed to a water quality program, as demonstrated by dedicated lab space, acquisition of modern analytical equipment, cooperation and assistance by all management branches of the park, and energy spent to find a source of continued funding. In the end, it is not the money that defines the program, but the dedication of the support personnel. Nonetheless, people drive the monitoring train, and without fuel, neither can go very far.

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Bald Eagle Research in the Apostle Islands National Lakeshore

By Julie Van Stappen and Michael Meyer

Figure 1 (map). Apostle Islands National Lakeshore, Wisconsin; site of the bald eagle biosentinel research.

Figure 2 (above). Bald Eagle chicks in nest at York Island.

Apostle Islands National Lakeshore is located in far northwestern Wisconsin (fig. 1). It includes 21 scenic islands in Lake Superior and a 19.2-km (12-mi) long strip of mainland. Bald eagles *(Haliaeetus leucocephalus)* (fig. 2) grace the skies above the islands; however, their low numbers have caused concern for both park managers and state resource management partners. Although eagles have increased in Apostle Islands and along the Lake Superior shoreline since DDT was banned in 1972, their reproductive rates have remained significantly lower than mainland populations. After years of monitoring and two research projects, we have begun to answer some questions about the eagle population at Apostle Islands.

Population Decline

As in most of its range, the bald eagle in the Apostle Islands declined significantly after the widespread introduction of toxic chemicals into the environment. By the 1970s, no more than 24 breeding pairs of bald eagles remained along all Great Lakes shorelines. In the Apostle Islands, bald eagles were absent throughout the 1970s. Between 1980 and 1983, eagles began to reestablish territories here, although they produced no young until 1983.

Eagle research conducted in the park from 1984-86 (Kozie and Anderson 1991) found high levels of contaminants in prey items and nestling carcasses. The majority of food eaten by eagles during the study was fish; however, gull remains were also found in eagle nests. Apostle Islands gulls have high levels of organochlorine contaminants. During the study (Kozie 1991), eagles along the Lake Superior shoreline (including the park) produced an average of 0.9 young/occupied nest with an average nest success of 57%; statewide averages during that period were 1.3 young/occupied nest and 75% nest success.

From 1989-93, the Wisconsin Department of Natural Resources and Michigan State University sampled eaglet blood and found higher levels of PCBs (polychlorinated biphenyls) in Apostle Island eaglets than mainland eaglets; these levels now appear to be decreasing. In 1991, we began a pilot study (Meyer and Van Stappen 1991) to explore causes of lowered eagle productivity in the lakeshore and the impact of toxic chemicals on productivity; we also began to develop a protocol using bald eagles as an ecosystem monitor species for Great Lakes water quality.

Eagles as Indicators

In 1992, The Great Lakes Protection Fund financed a greatly expanded project. A primary focus of this study was to obtain data needed to develop a Great Lakes bald eagle biosentinel protocol; in 1990, the International Joint Commission recommended use of the bald eagle (and specifically its reproductive rate) as a bioindicator of "ecosystem health" and water quality in the Great Lakes basin (International Joint Commission 1990). This multiagency-university study included the Wisconsin Department of Natural Resources, Apostle Islands National Lakeshore, University of Minnesota, and University of Wisconsin.

Before using the bald eagle as a biosentinel, the relationship between contaminants and eagle productivity needed further study. Primary factors suspected of lowering productivity of Lake Superior eagles included environmental contamination, low food availability, and harsh weather.

Research Gets Underway

During the 1992-93 field seasons, we conducted research along the Lake Superior shoreline, including the Apostle Islands, and at mainland Wisconsin bald eagle nest sites (fig. 3). We used direct and remote video camera observations to study eagle behavior through the help of Keith Warnke (University of Minnesota) who focused his master's thesis on analyzing these operations. We also used these techniques to determine nestling food-energy intake by determining the rate of prey delivery. Field metabolic rate on eaglets in control nests was measured

Figure 3. Park tree climbers retrieved chicks for marking and blood samples.

using a doubly-labeled-water technique to validate observational data. Dr. Cheryl Dykstra of the University of Wisconsin focused her Ph.D. dissertation on this technique, which is used to measure energy expenditure by simultaneously measuring metabolizable energy intake in a feeding trial.

Research results indicate that Lake Superior nestlings in broods of one chick received about the same amount of food as did interior mainland nestlings in broods of one chick. However, Lake Superior nestlings in broods of two chicks received *significantly less* food than interior mainland broods of two chicks. Likewise, Lake Superior adults spent approximately 20% less time at the nest during the early nestling stage, and mortality in Lake Superior nests of two chicks was significantly higher than in interior mainland nests (27.3% vs. 8.6%). Nestlings at shoreline nests with two nestlings also modified their behavior to conserve energy by spending significantly less time feeding, being active and standing in the nest, and more time lying in the nest.

We tested the potential relationship between contaminants and productivity by analyzing eaglet blood and addled eggs. Between 1989 and 1993, blood samples were collected from 83 bald eagle nestlings in Wisconsin, 33 of which were along the Wisconsin shoreline of Lake Superior. Lake Superior nestlings contained elevated levels of DDE (a breakdown product of DDT) and PCBs. The highest concentration of PCBs (1,154 ppb) was found on Michigan Island in 1992 in the Apostle Islands National Lakeshore; there the nest is located about 1.6 km (1 mi) from a large herring gull and double-crested cormorant colony. Documentation shows that the eagles fed on both species in 1992.

The mean Wisconsin Lake Superior nestling plasma PCB concentration (100 µg total PCB/l plasma) was three times greater than interior mainland Wisconsin nestling plasma PCBs; however, this level is 45% less than the average plasma PCB concentration for Michigan and Ohio Great Lakes nestlings. Concentrations of DDE and PCBs in eggs collected on Lake Superior declined between 1969 and 1993. The DDE levels in eggs collected during the early 1990s were at or below the level (4 µg DDE/g egg fw [fresh weight]) considered to impact productivity. This indicates that Lake Superior eagle productivity may no longer be affected by these contaminants. In addition, Wisconsin Lake Superior egg PCB levels (14 µg total PCBs/g egg fw) are dramatically less than levels in the 1970s; they are now comparable to Wisconsin River egg PCB levels where productivity rates are excellent.

The research assessed Wisconsin eagle productivity through aerial overflights during incubation and again when chicks were 4-7 weeks old. For more than 25 years, Mr. Charles Sindelar (Waukesha, Wisconsin) and the Wisconsin Department of Natural Resources have conducted these overflights. From 1983-94, productivity of Lake Superior bald eagles was significantly lower than that of interior mainland eagles. However, it has been improving; more than one young per occupied territory was produced during five of the past eight breeding seasons.

We did not find weather to be a significant factor in lowering productivity, with the possible exception of when Lake Superior completely freezes over. For the first time in 17 years, Lake Superior was completely ice covered in January 1994. During the first aerial overflight, six eagle nests in the Apostle Islands were active, but only one nest hatched chicks. Unfortunately, the two hatchlings were later preyed upon. An examination of the failed nests was inconclusive; however, most appeared to have been abandoned during incubation.

Results

Results of this research indicate that the most likely cause of lower bald eagle productivity along the Lake Superior shoreline is low food availability. Low food abundance following hatching may be leading to low food delivery rates to chicks or prolonged adult foraging time away from the nest, resulting (indirectly) in increased chick mortality. The ratio of young produced per *successful* nest is consistently less on the Wisconsin Lake Superior shoreline than at interior Wisconsin nest sites; in raptors this productivity ratio is stable across wide geographical areas, only declining when nests are established in marginal habitat. The Wisconsin Lake Superior bald eagle productivity rate also fluctuates greatly, some years approaching the rate of a "healthy" population, only to be followed the next year by extremely poor reproduction (e.g., 1993–1.03 young per occupied territory; 1994 (Lake Superior ice-covered)–0.33 young per occupied territory; 1995–1.07 young per occupied territory). It is likely that reduced food availability chronically depresses Wisconsin Lake Superior bald eagle productivity and this effect is exacerbated during harsh weather conditions. The Wisconsin Lake Superior bald eagle nest density is low and the rate of increase has leveled off after a rapid expansion in the 1980s; this is in contrast to the rapidly expanding mainland Wisconsin population that continues to grow at an

Before using the bald eagle as a biosentinel, the relationship between contaminants and eagle productivity needed further study.

Continued on page 26, column 3

Leave No Trace

Outdoor Skills and Ethics:

An Educational Solution for Reducing Visitor Impacts

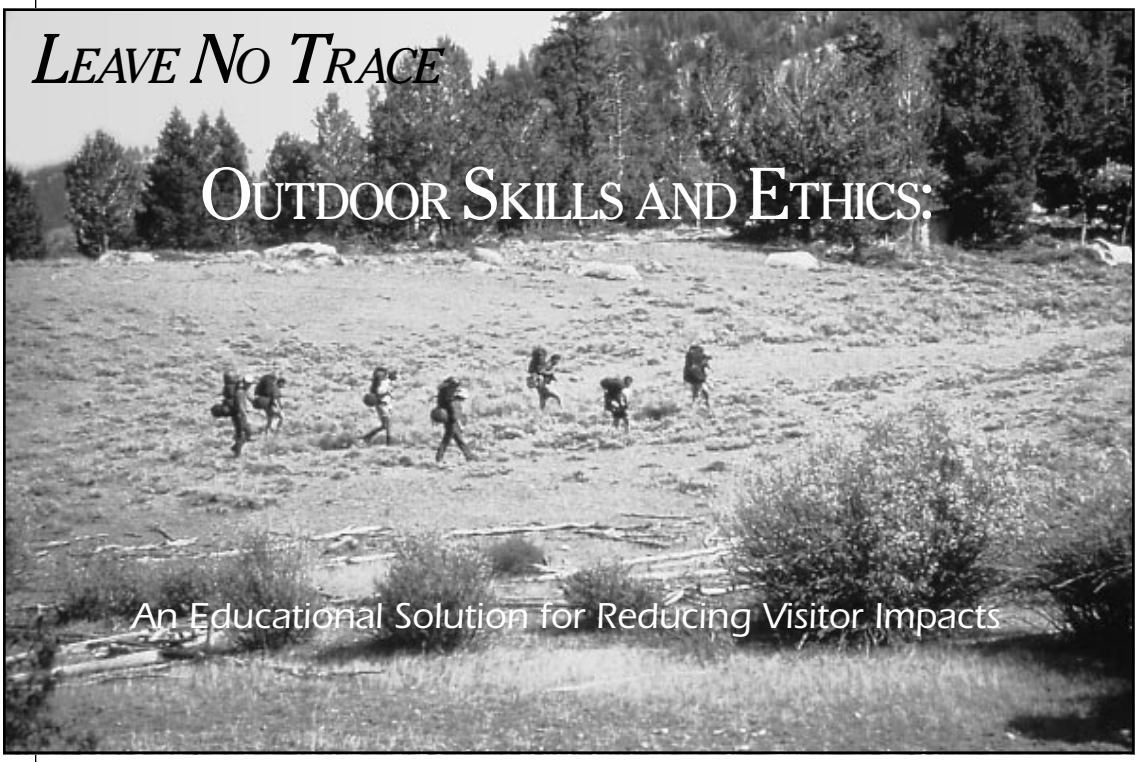

Figure 1. Leave No Trace hiking practices advise off-trail hikers to avoid creating new trails by traveling on durable surfaces and not walking in single file.

By Jeffrey L. Marion and Susan Chadwick Brame

Visitors to national parks and wildlands pose an unintentional but very real threat to the naturalness of these protected environments. Opportunities for recreation constitute a primary purpose for the establishment of these national treasures, challenging managers with the difficult task of balancing recreation and resource protection objectives. As visitation continues to increase, the recurring question, "Are we loving our parks to death?," compels managers to search for new and more effective tools to reach that balance.

In fulfilling their mandate, managers have employed a wide array of direct and indirect visitor management actions (see Marion et al. 1993). Direct actions, such as prohibiting campfires, alter visitor behavior through regulations that reduce visitor freedom, an important element of high quality wildland experiences. Indirect actions, such as visitor education, encourage visitors to voluntarily alter their behavior to lessen the environmental impacts of their recreational pursuits. Educational approaches seek to convey information that emphasizes the linkage between visitation and resource degradation. Camping and hiking practices that reduce visitor impacts are promoted along with outdoor ethics and judgment necessary to guide the selection and application of low-impact skills.

This article describes a new and rapidly growing national *Leave No Trace* (LNT) outdoor skills and ethics program that promotes responsible backcountry recreation (fig. 1). The effort unites four federal agencies–the National Park Service, U.S. Forest Service, Bureau of Land Management, and U.S. Fish and Wildlife Service–and outdoor retailers, manufacturers, user groups, educators, and individuals who share a commitment to maintain and protect our public lands. The primary goal of the program is to develop an educational system that instills the desire and understanding, and demonstrates the necessary skills, to enjoy outdoor recreation in a low-impact manner. The program makes *Leave No Trace* a household name for many Americans, similar to other federal campaigns such as Smokey the Bear and Woodsy Owl.

History and Description of the *Leave No Trace* Program

The *Leave No Trace* program was formalized in 1993 with a memorandum of understanding between the federal partner agencies and the National Outdoor Leadership School (NOLS). NOLS is a nonprofit wilderness school, with international headquarters in Lander, Wyoming. Over the past 30 years, NOLS has taught wilderness and leadership skills to 40,000 individuals on its expedition-based courses around the world. The *Leave No Trace* program had its origins in the 1970s in the U.S. Forest Service, when use of wildlands soared, and education became imperative for wildlands to retain their pristine qualities. However, lack of funding limited efforts until 1991, when the Forest Service approached NOLS to serve as a partner in the program. Further, *Leave No Trace,* Inc., a nonprofit corporation in Boulder, Colorado, was formed in 1994 to oversee marketing efforts and industry fundraising for the program. They function in cooperation with the original partners, representatives of the outdoor products industry, conservation organizations, and major recreational user groups.

The current LNT programs build upon previous educational efforts but are distinguished from their predecessors in three fundamental aspects. First, they are more thoroughly grounded in scientific knowledge from the discipline of recreation ecology. Knowledge from this discipline describes relationships between resource degradation and different types and amounts of recreational use, as modified by environmental factors (e.g., vegetation or soil types) and managerial factors (e.g., visitor management actions).

For example, LNT literature instructs visitors to apply different practices depending upon whether they are in high-use areas or less visited pristine areas. Selecting durable vegetation types and surfaces for travel and camping is also emphasized.

Second, current efforts place substantial emphasis on hands-on training, both of LNT trainers and backcountry visitors. The heart of the program is the Master of *Leave No Trace* Course, a 5- to 6-day field course with three components: 1) low-impact camping and travel skills, 2) wildland ethics, and 3) teaching techniques. Successful graduates teach agency personnel, their constituents, and the public about *Leave No Trace*. Diverse participants in each course enhance the educational experience. Some of the nonfederal participants include members of scouting groups, numerous colleges, private outfitters, and outdoor product industry representatives. Inherent in the LNT training philosophy is the obligation of "masters" to teach and encourage others in *Leave No Trace* skills and ethics. Masters train trainers that can assist them in reaching the public with as much hands-on instruction as possible.

The growing cadre of LNT masters (currently 333 individuals in 32 states, Mexico, and Chile) is supported by follow-up and curriculum assistance from NOLS and participating agencies. The masters are networked through the thrice-yearly Master Network newsletter and the LNT World Wide Web site on the Internet (http://www.nols.edu/LNT/LNTHome). NPS staff who are interested in the Master of LNT training or in receiving the LNT newsletter should contact the NOLS LNT office (1-800-332-4100; e-mail "lnt@nols.edu").

Finally, the current program is developing and distributing a comprehensive set of LNT literature targeted to a wide variety of audiences. The NOLS LNT office distributes 12 different publications and three videos, including a definitive book, "Soft Paths: How to Enjoy the Wilderness Without Harming It" (Hampton and Cole 1995), several national LNT pamphlets and posters, a regional series of LNT outdoor skills and ethics booklets, an activity-specific series (*Leave No Trace* for horseback riders and climbers), and most recently, a LNT booklet developed specifically for Great Smoky Mountains National Park. The program also has a toll-free number (1-800-332-4100) for requesting LNT literature. In the last four months of 1995, NOLS staff received an average of 22 phone calls a day, and sent out 434 LNT mailings. Additionally, LNT literature is posted on and may be requested over the World Wide Web.

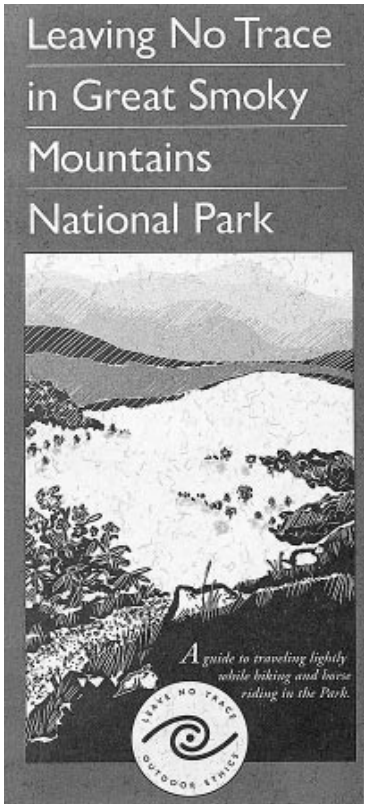

Figure 2. Brochures, like the one for Great Smoky Mountains National Park, are one means to publicize the program.

Leave No Trace Pamphlet for Great Smoky Mountains

The need and opportunities for developing specific LNT literature are highlighted in the remainder of this paper. Existing national, regional, and activity-specific LNT literature conveys skills and practices that are widely applicable. However, specific practices, such as selecting and using a pristine campsite, may not be applicable in parks that restrict camping to designated sites. Visitor management regulations adopted by different parks to limit visitor impacts may appear to conflict and may confuse park visitors. For example, Shenandoah National Park minimizes backcountry camping impacts by dispersing camping while their southern neighbor, Great Smoky Mountains, has adopted designated site camping regulations to limit impacts. Camping impacts can be effectively minimized under both impact reduction strategies, but educational efforts must be tailored for each to maximize its effectiveness.

Developing park-specific LNT literature (fig. 2) enables managers to include only those practices that are applicable to their unique environments, activities, and management practices. *Leave No Trace* practices that address particularly troublesome impact problems, such as firewood collection and fire building, can be emphasized. Different LNT practices can be targeted to different user groups (e.g., hikers or horseback riders) or for different park environments (e.g., river or desert). Additionally, LNT information can explain the rationale for visitor regulations and describe low-impact camping and hiking practices that increase the effectiveness of those regulations.

Managers, visitors, and park backcountry resources all benefit from national visibility and consistency of the LNT program. Visitor compliance and ethical understanding are enhanced when educational tools are reinforced and amplified by outdoor stores, the media, scouting and other groups, and park staff. The national program does not replace local educational efforts; it strengthens them by providing a broader context.

I had an opportunity to pilot test the development of park-specific LNT literature during recent campsite and trail survey research that I conducted at Great Smoky Mountains National Park. Along with NOLS and Great Smokies Resource Management Specialist Carol Schell, we developed and submitted a Challenge Cost-Share proposal for NPS funding to create and publish a Great Smokies *Leave No Trace* brochure. The National Park Service and NOLS funded the proposal in 1994 in the amounts of $8,500 and $10,800, respectively.

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Leave No Trace continued

National Outdoor Leadership School project writer Susan Brame worked closely with Carroll Schell during the winter of 1994-95 to write the booklet. They gathered and examined existing park information regarding backcountry regulations, rationale for the regulations, and low impact camping and hiking practices. This information was integrated with LNT practices described in the Southeastern States LNT Outdoor Skills and Ethics booklet and other sources to produce a LNT booklet that is directly relevant and specific to Great Smoky Mountains. Staff at NOLS, the park, and the Virginia Tech Cooperative Park Studies Unit reviewed two drafts of the text that was then sent out for an external review. After incorporating comments and edits, NOLS arranged for printing. Donations from NOLS alumni in the southeastern United States increased funding available for the initial printing. We completed and mailed the attractive 15-page booklet (3½" x 8")in July, and it has been well received.

Like most parks, Great Smokies faces myriad backcountry recreation management challenges, and they must cope with budget cuts that require constant innovation. Through the generosity of a local donor, managers created a short educational video to cover the basics of minimum-impact backcountry travel. According to Chief Ranger Jason Hock, the brochure was integral to the whole process.

The success of the Great Smokies partnership provides a useful model for other parks. Several ongoing LNT partnerships are pursuing slightly different tactics. The NOLS *Leave No Trace* staff is currently working with nine western parks to develop a Rocky Mountain LNT video. NOLS is also involved in a grant-funded, 3-year partnership with the Wyoming office of the Nature Conservancy; the purpose of the project is to gather information about visitor impacts and develop a recreational strategy with LNT education for the Conservancy's Tensleep Preserve.

These examples illustrate only some of the possibilities for developing tools and strategies to improve visitor education. Less intensive forms of involvement might include the distribution of electronic copies of existing LNT literature, with modifications made by park staff. NOLS can serve in a review role to ensure accuracy and consistency and coordinate approval with LNT, Inc., for use of the LNT logo. Every successful partnership, in whatever form, will enhance the next effort.

National Park Service staff interested in exploring partnership opportunities should contact Rich Brame at NOLS. While the level of NOLS involvement is contingent on available funding, they are committed to LNT education and will work with managers to develop strategies that work.

Using research to determine relationships between resource degradation and use, the Leave No Trace *Program promotes responsible, low-impact backcountry recreation through education*

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Bald eagle research continued

exponential rate. Other contributing factors to lowered productivity include: lowered nest attentiveness; higher predation rates of young; harsh spring weather or extensive ice cover; and somewhat elevated levels of PCB and DDT.

In Closing

Eagle research methods and findings in the Great Lakes have been incorporated in the development of a Great Lakes bald eagle biosentinel protocol. The protocol is currently under consideration for adoption under the Great Lakes water quality agreement between the U.S. and Canadian governments. This protocol, if adopted, will standardize methods used by numerous state, provincial, and federal agencies to collect Great Lakes bald eagle habitat, productivity, and contaminant data, allowing the Apostle Islands eagle population to be put into a regional framework. However, the results of this project must be considered carefully when comparing productivity trends between Lake Superior and the other Great Lakes. In the other lakes, contaminants may be the primary factor limiting productivity, whereas food availability appears to be the primary limiting factor in Lake Superior. This knowledge will enable us to better interpret population trends in the Apostle Islands eagles.

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Turfgrass Research in Washington, D.C., Area National Parks

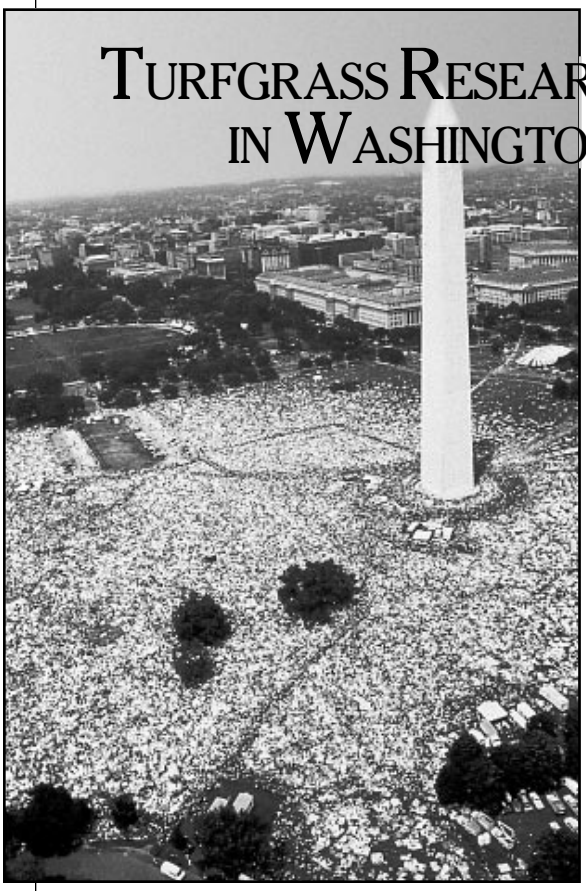

Figure 1. The Fourth of July celebration on the Washington Monument grounds in Washington, D.C., poses a real challenge to turfgrass managers. As many as 1,000,000 people turn out for the annual fete, compacting grasses and wearing them down to dirt.

By Kevin N. Morris and James C. Patterson

Editor's note: *Turfgrasses are predominantly nonnative, require regular care that at times may not be ecologically sound, and are not appropriate in many areas of the national park system. This article does not discuss policy issues related to where and when turfgrass should be used. Rather, it is intended to help managers make wise turfgrass choices in parks where the use of sod is long-established and considered appropriate.*

What do kite flying, gatherings like the Million Man March, and visiting a soldier's grave all have in common? Each is an activity that takes place on *turfgrass* in units of the national park system. While the presence of healthy sod is not the focus of such activities, it is a key component in providing for visitor use and enjoyment, especially in urban or historical parks.

The demands we make on turf in national parks are diverse and often overlooked. Turfgrass should blend in with the natural surroundings and not become a focal point, whether beautiful, deep green, withered, or dead. In historical parks, turf may need to match the cultural landscape being presented as a snapshot in time. In recreational settings, turfgrass needs to be durable and stand up to constant compaction from large gatherings. Around visitor centers and other park facilities, turfgrass may simply be used to help beautify an area.

Turfgrass, however, plays a much more important role than just providing beauty. Made up of miles of roots, thousands of grass plants per square yard help to conserve and stabilize soil. A thick, healthy turfgrass stand is a natural filter that absorbs great quantities of rainfall, purifying it as it slowly drains into the soil. Grass provides a natural cooling effect on hot summer days by reducing air temperatures at the ground 15-30 degrees Fahrenheit. Turfgrass is also a pleasant, safe surface for informal games and picnics or formal organized sports. The challenge is to develop and keep turfgrass stands that provide these benefits but do not require constant care, pampering, or great expertise to manage.

Managers now recognize the increasing importance of adopting sustainable management practices in both natural and cultural resource parks. For certain park purposes, native grasses may be a good choice for low maintenance, but they may not hold up to the pressures of high use areas. Furthermore, they may not be available for use in many cultural park settings. Turfgrasses on the other hand, require attention that may not be environmentally sound. Use of natural or artificial pesticides, for instance, have potential negative environmental effects and can be costly to purchase and apply. Additionally, nearly all turfgrasses are nonnative.

Turfgrass Research

So how do we select and grow good turfgrass in parks with minimal effort, cost, and disturbance to ecosystems? Turfgrass research has answered many of these questions (see the companion article on turf selection and care on page 30) and continues to be important in making site-specific recommendations. Since 1979, the NPS National Capital Field Area has participated with the National Turfgrass Evaluation Program (NTEP) in conducting turfgrass research. This program is sponsored by the National Turfgrass Federation, Inc., and the United States Department of Agriculture in Beltsville, Maryland, and coordinates testing of over 600 grasses across the United States and Canada. The program accepts new genetic seed stock from seed companies and plant breeders, organizes and mails seed to cooperating colleges and universities and other interested technical participants, collects test results, and releases data summaries. The cooperating university turfgrass researchers prepare, seed, tend, and evaluate the research plots. Each individual test is programmed for a 4-5 year field evaluation. The study period spans different weather conditions and use situations, thus providing an excellent overall evaluation of performance. Also, since tests are located in many geographic

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areas, excellent *cultivar* (short for "cultivated variety," which means improved strain) recommendations can be developed for local turfgrass users in most any area.

The National Park Service is interested in evaluating cultivar performance on heavily impacted, low maintenance park lands. Tests have been planted and evaluated on the Washington Monument grounds, National Mall, and East Potomac Park in Washington, D.C., Prince William Forest Park in Northern Virginia, and Antietam National Battlefield in Sharpsburg, Maryland. The growth conditions at these sites are different from those of the university experiment stations across the continent largely because of the tremendous impact that visitors and their feet have on grass and soil. For example, approximately 1,000,000 people visit the Washington Monument grounds on the Fourth of July (fig. 1, page 27) where the soil compacts nearly as hard as concrete. Likewise, the wear and tear on the National Mall turfgrass is tremendous considering 13-33 million people visit this site annually. In 1991 alone, approximately 2,100 permits, or seven per day, were requested for events as benign as a one-person newscast to very large gatherings on the National Mall. The Gulf War victory celebration brought over 1,000,000 people to the National Mall to view military hardware (fig. 2). Everything from tanks to Apache helicopters to harrier jets were displayed, most on the grass, making the need for sound resource management recommendations obvious (fig. 3).

The lion's share of the cooperative research has been on the Washington Monument grounds. We have planted, grown, and evaluated experimental plots there continuously since 1980. We have tried many grasses and varieties and most have failed the test! Only a handful of Kentucky bluegrass (fig. 4) and perennial ryegrass varieties have delivered acceptable results and even fewer tall fescues have survived over the years.

Conducting research on a national park site is not always as easy as a university or USDA experimental area, for researchers must control as many variables as possible. We go to great pains to find uniform, level soils, provide measured, accurate applications of water and fertilizers, and follow time-honored data collection procedures and analyses. However, at park sites, some variables are not controllable. For instance, construction workers parked heavy equipment on a tall fescue evaluation plot near the Smithsonian Institute and built a fence around it. Another plot was covered with straw and artificial walkways for the display of twelve acres of quilts just 3 weeks after seeding! Trucks, large tents, concert stages, and display booths have all covered our sites, and engineers have constructed new sidewalks through or next to them. Even on occasion, marijuana "grass" seed can be found, so thoughtfully dropped or left behind by others.

Figure 2 (above). The Desert Storm celebration, held in June 1991 on the National Mall, drew 1,000,000 people over 4 days to view 20 pieces of military hardware on display.

Figure 3 (right). Just 6 weeks after being worn to dirt, the same helicopter display site has bounced back solely as a result of watering. Kentucky bluegrass is generally resistant to compaction, but cultivars differ in their resilience—see figure 4.

Other cooperative research projects include testing grasses in heavily shaded areas that have compacted soils and improving a very acidic, pyrite mine spoil site with compost materials in Prince William Forest Park. Antietam National Battlefield offers additional research opportunities for evaluating grasses in a national cemetery. The battlefield is also evaluating a soil amendment for its potential to limit soil compaction in a well-worn grass walkway.

Research Methods

The National Turfgrass Evaluation Program conducts experiments using small (25 square foot) plots of each grass type. Initially, a test area is selected based on suitability to the test. If the primary goal is learning the incidence of disease, then we locate tests in areas with heavy disease pressure or in areas where disease can run rampant. For example, summer diseases need high temperature, high humidity, and moist conditions to thrive. Therefore, areas with low relative elevation or areas next to woods provide additional moisture or restricted air flow that encourages disease development. If the objective is to test tolerance to compaction or traffic, we choose areas that provide a uniform, consistent wear pattern across the experiment. Drought tolerance can be tested using reduced or no irrigation. Cold tolerance can be evaluated by planting the grasses outside their zone of adaptation.

A test area needs to be uniform in soil type, drainage, etc., so that differences in soil or water- holding capacity will not give one grass an advantage over another. All vegetation is removed from the site, the area is cultivated, fertilized, and prepared into a firm, smooth seedbed. Then, a measured amount of each seed is planted using a 5 x 5 ft planting box to prevent the seed from blowing into adjacent plots. After seeding, the entire area is covered with seeding cloth to prevent washing of the seed.

Each grass is planted, or replicated, three times in a random fashion to further negate any differences in soil, drainage, or disease development in the plot

Figure 4. This national Kentucky bluegrass test plot—cultivar ISI-21—persists in good health 3 years after establishment on the Washington Monument grounds; all other surrounding bluegrass cultivar plots have died.

area. Replications allow the researcher to determine if the response of one grass to a particular stress is accurate or happened by chance. If one plot of a cultivar is damaged from disease but the other two plots are not, then uniform disease development did not occur. If all the grasses in one corner of the plot are infested with a particular insect but do not show damage in other areas, then the insect is not distributed uniformly.

The National Turfgrass Evaluation Program has developed a standardized data collection format that all cooperators use when collecting data. Data on many characteristics is collected by the researcher: some data characterize or describe each grass (descriptive) and others record the grasses' response to various stresses. Examples of descriptive characteristics are leaf texture (fineness of leaf), genetic color (shade of green), and density (number of plants per unit area). These characters are collected at many sites and do not vary much from location to location.

Stresses that may influence the quality of a turf stand include diseases, insects, drought, heat, cold, poor soil, low fertility, wear and tear, and others. Researchers attempt to rate the grasses' response to these various stresses as they occur. Often, however, several stresses may affect a grass at one time, making it difficult to separate responses to each stress. Therefore, researchers collect the most important rating, turfgrass quality, each month throughout the growing season. Quality ratings reflect many factors including leaf texture, color, density, disease and insect tolerance, weed invasion, drought, and cold.

Many turfgrass characteristics are subjective, due to personal bias of the researcher. This significantly influences whether a grass receives a high or low rating for turfgrass quality. Some characteristics, such as depth of thatch, can be measured quantitatively. However, measurements of many characteristics are difficult and time consuming to make. Therefore, researchers use the NTEP format and rate most grasses on a scale of 1-9 with 9 being highest quality, darkest green, finest leaf texture, least disease, etc. With proper training, test personnel can become quite proficient in rating grasses quickly and accurately.

After data is collected for an entire growing season, they are assembled and sent to our facility in Maryland. We check the data, correct inaccuracies and perform statistical analyses on each data set. Annual progress reports are produced containing all the data collected on each turfgrass species from each location. These summaries are available for a modest fee.

Applying the Research

The test data have been used for many other national park system areas where recommendations to improve turfgrass are required. Generally the areas most in need of these recommendations are those with large acreages of grass where park visitors tend to gather. By providing the improved turfgrass recommendations, soil test data, and improved management guidelines, a much improved, functional turf stand is achieved. This is particularly important when one considers that over 100 Kentucky bluegrass cultivars are on the market and, without field testing, selecting the right variety for any single site is very difficult. The same is true for tall fescue, fineleaf fescue, perennial ryegrass, zoysia, and other grasses (see Table 1, page 31). For example, "Monopoly" is a Kentucky bluegrass cultivar that has performed consistently better than most grasses tested over the past 15 years on the Washington Monument grounds. This cultivar is lighter green and generally less attractive than many others, but it withstands heavy foot traffic and resulting compacted soils. "Midnight" Kentucky bluegrass, on the other hand, is an attractive, dark green, dense cultivar that has never survived more than 1 year in the Washington Monument tests.

The three research partners have also cooperated to improve the turfgrass quality of the National Mall. This project involved installing a zoysia and tall fescue plot near the Smithsonian Institute and the Capitol. The objective was to provide ideal conditions by encouraging the zoysia in summer and then managing the tall fescue during the winter. This mix provides a good balance as zoysia prospers under hot, dry, and heavy use conditions prevalent in summer, while tall fescue performs well during the cool, moist winter months. This mixture has performed well and remains under evaluation. If it proves acceptable, then the National Park Service will alter its management of the mall turfgrass.

A further example of the usefulness of these data is the need for improved grasses on Liberty Island where the Statue of Liberty resides in New York City. Liberty Island receives heavy visitation and impacts similar to those of the Washington Monument grounds. Data collected at the Washington Monument, other park sites, and nearby Rutgers University in New Jersey, have lead to improved turfgrass recommendations for the Statue of Liberty. Perhaps other parks will benefit from this research.

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A Primer for Choosing and Maintaining Healthy Turf

By Kevin N. Morris and James C. Patterson

RESEARCH, AS DISCUSSED IN the article on page 27, is important to fine tune turfgrass recommendations to a specific park or for a particular function. However, much basic information on the attributes of various turfgrass varieties is already available from earlier studies and may be helpful to park managers.

The first step in growing good turfgrass with minimal effort, cost, and disturbance to ecosystems is very basic–choosing the proper grass for the geographical area and intended use. Grasses come in many varieties and flavors, but can be broken down into two categories: cool-season and warm-season. As the name suggests, cool-season grasses grow best in spring, winter, and fall, and prefer the cooler areas of the United States. Extending the Mason-Dixon line west across the country roughly gives the southern border of this region. Logically, warm-season grasses that grow best in warm, summer temperatures, are best south of the Mason-Dixon line, right? Unfortunately, the line is not nearly this clear-cut. Many of the warm-season grasses do not like cold, winter temperatures that prevail from Maryland south to Georgia and even to the mountains of, say, Arizona. Therefore, the grass-type decision process is quite muddled and very confusing at times.

To further complicate the issue is the consideration of the location and use for that grass. Is the area in full sun or shade? Is the soil acidic or alkaline? Will hordes of visitors trample the grass? Many other questions are pertinent, but the point is that choosing the best turfgrass is work! While managers should expect to give attention to the care of turfgrass, choosing the right grass from the start will minimize problems and reduce costs down the road (Table 1).

Cool-season Grasses

Cool-season grasses have the widest distribution and greatest use in most areas of the United States. The most popular cool-season grasses are Kentucky bluegrass *(Poa pratensis),* perennial ryegrass *(Lolium perenne),* tall fescue *(Festuca arundinacea),* fineleaf fescue *(Festuca rubra)* and creeping bentgrass *(Agrostis stolonifera)*. None of these grasses are native to the United States. Most were brought from Europe when immigrants or sailors crossed the Atlantic with seed or bedding for cattle on board.

Kentucky bluegrass (which did not originate in Kentucky, but grows well there) is widely used because it is attractive, forms a dense sod, and comes in many variants. Some Kentucky bluegrasses arc very tolerant of foot traffic, while others tolerate acidic soils, shade, or drought. Unfortunately, no single Kentucky bluegrass has all these characteristics; you must first identify your needs and choose accordingly.

Perennial ryegrass germinates fast, quickly establishes ground cover, and is also fairly tolerant of walking or sports-related wear and tear. Its downfall, in the humid states, is its susceptibility to damage by summer diseases.

Tall fescue is heat and drought tolerant while requiring less fertilizer and water than perennial ryegrass and most Kentucky bluegrasses. The "transition zone," an area that is too cold in winter for many warm-season grasses and too hot in summer for many cool-season grasses, is the best area for use of tall fescue. It does well in acidic soils, but does not tolerate compacted soils. Therefore, it is not the best choice for most heavy traffic areas.

Fineleaf fescues (a general term for six different grass species) are excellent in shade and also perform well in poor, acidic soils. They require a minimum of fertilizer and water and perform poorly when too much fertilizer is applied. These varieties tolerate compacted soils very poorly and are not suitable for high visitation areas. Very low maintenance areas, such as cemeteries and roadsides, are traditionally where fineleaf fescues have been used, but they are making their way into more turf settings.

Creeping bentgrass is a specialty grass used mainly on golf courses and probably has very little utility in most national parks.

Warm-season Grasses

Warm-season grasses, such as Bermudagrass *(Cynodon sp.),* zoysiagrass *(Zoysia sp.),* centipedegrass *(Eremochloa ophiuriodes)* and St. Augustinegrass *(Stenotaphrum secundatum),* like their cool-season counterparts, are native to other parts of the world, coming here via settlers or travelers. Buffalograss *(Buchloe dactyloides),* on the other hand, is native to the U.S. Great Plains. These grasses thrive in summer heat and are more tolerant of drought, in general, than the cool-season grasses. Warm-season grasses vary, however, in their ability to tolerate extreme drought, cold winter temperatures, and disease.

Bermuda grass is probably the most widely used of the warm-season grasses. Bermuda grass spreads very fast and forms a dense sod with very good drought and wear tolerance. Hybrid Bermuda grasses form a very dense, fine-textured turf but require higher maintenance than available at most parks. Common Bermuda grass will survive with less care than the hybrids but still requires a higher level of maintenance than some other warm-season grasses.

Zoysiagrass spreads much slower than Bermuda grass but forms a denser sod with lower fertility requirements. Many zoysiagrasses are very cold tolerant and will survive winters in the northern United States.

Centipedegrass is fairly coarse-textured and slow-growing but needs less fertilizer and water than any of the other warm-season grasses. The cold tolerance and wear tolerance is medium to low. St. Augustinegrass has very coarse leaves and forms a sod that feels "spongy." This grass spreads quickly and has the best shade tolerance of any of the warm-season grasses. However, this grass also has the least tolerance of cold and wear.

Grass Care

After choosing and establishing a grass, a manager needs to consider mowing, fertilizing and watering the turf. Since turfgrasses are often not cut or mowed in nature (except where grazed by animals),

Table 1. Advantages and Disadvantages of various grasses

Variety	Pros	Cons
Cool-season grasses	Grow best during cool season and cool regions of U.S.	
Kentucky bluegrass varieties	Tolerant of foot traffic, acidic soils, shade, and drought	No single variety offers all these characteristics
Perennial ryegrass	Germinates and covers quickly; fairly tolerant of soil compaction	Susceptible to summer diseases
Tall fescue	Heat and drought tolerant; uses less fertilizer and water than perennial rye and kentucky bluegrasses; does well in acidic soils	Does not tolerate compacted soils
Fineleaf fescue varieties	Excellent in shade and acidic soils; require little fertilizer and water; good for low maintenance areas like cemeteries and roadsides	Intolerant of compaction
Creeping bentgrass	Specialty grass of golf courses	Large water volume and high maintenance
Warm-season grasses	Thrive in summer heat; tolerant of drought	May not do well in transition zone to cold areas; vary in ability to tolerate extreme drought, colder temps, and disease
Bermuda grass	Spreads fast; dense; drought and wear tolerant	Requires higher maintenance than some other warm-season grasses
Hybrid Bermuda grasses	Spread fast; dense; drought and wear tolerant	Require higher maintenance than Bermuda grass
Zoysiagrass	Forms dense sod with low fertilization requirement	Spreads much slower than Bermuda grass
Centipedegrass	Needs least water and fertilizer of any warm-season grass; forms denser sod, with less fertilization, than Bermuda grass	Spreads more slowly than Bermuda grass; course-textured; slow growing; medium to low cold- and wear-tolerance
St. Augustinegrass	Very course leaves give a spongy feel; spreads quickly; best shade tolerance of any warm-season grass	Least cold- and wear-tolerance

mowing is the maintenance practice that can most easily damage turfgrass stands. Therefore, proper mowing procedures are essential for healthy grass that is able to withstand weeds, diseases, and insects. A good guideline is to never remove more than one-third of the height of the grass with any one mowing. Grasses need an adequate amount of leaf tissue to perform photosynthesis and produce enough food to survive and thrive. Removing more than one-third of these leaves weakens the grass plant and may force it use stored food to "breathe." In addition, a sharp mower blade is important to produce a clean cut of the leaf blades and not cause damage to the tip of the grass plant. Finally, cutting height varies depending on the grass and needs to be researched and monitored for each mowing. Mowing shorter than a grass can withstand will severely damage the turf stand and will reduce the density of that stand, creating opportunity for weeds to invade.

Fertilization may or may not be performed in many national park sites, but it is important to understand the most important nutrients required by grasses. Nitrogen is the single most important element needed by grasses. Nitrogen causes leaves and roots to grow and improves the green color. Nitrogen can be overused however, therefore care should be taken not to apply more than the grass needs for adequate growth. Since the need for nitrogen varies with the grass type, consult a knowledgeable source for guidance. Phosphorus is the second element that is important for turfgrass survival. Phosphorus applications are most important during establishment of new seed or grass plants. After grasses are well established, phosphorus requirements are much lower than nitrogen requirements. Potassium, the third nutrient of importance, is probably not used enough by turfgrass managers. Potassium increases the heat, cold, drought, and wear tolerance of turfgrasses. Annual application rates of potassium that at least equal the rate of nitrogen used will help grasses to survive stressful periods.

Watering, or irrigation, is the final critical maintenance practice for turfgrass success. In many park situations, irrigation may be unavailable, impractical, or inappropriate. In many areas, such as the desert southwest, grass cannot be grown without supplemental irrigation. Therefore, water may be the limiting factor in growing good turfgrass. In many other areas, turfgrass can be grown successfully without irrigation, providing that the grass has an opportunity to first become well established. Irrigation, like fertilization can be overdone to the point that diseases and weeds become problems. Also, irrigation that promotes excessive grass growth during a stressful period, such as summer, may not allow grasses to "harden-off," or slowly prepare for stress. If irrigation is suddenly stopped, for economic or logistical reasons, the turfgrass will likely suffer more than if it were not irrigated and allowed to shut itself down. Most grasses can withstand at least some heat and drought stress and should, in most cases, be allowed to do so. If the area is needed as an attractive focal point for the park or for the safety of organized sports participants, then irrigation may be essential to ensure consistent turfgrass cover.

Meetings of Interest

SEPTEMBER 9-20 Front Royal, Virginia, will be the venue for the technical conference, Biodiversity Monitoring at Permanent Plots. Contact the Smithsonian Institution/MAB Program, 1100 Jefferson Drive, SW, Suite 3123, Washington, DC 20560; fax (202) 786-2557, for more information.

SEPTEMBER 14-19 Florence, Italy, will play host to the 17th International Meeting for specialists in air pollution effects on forest ecosystems. Entitled, Stress Factors and Air Pollution, the gathering will focus on recently discovered effects of air pollutants on forest ecosystems, with special reference to the interactions between environmental stress factors. Sessions include: interactions between air pollutants and abiotic and biotic stress factors; impacts on wildlife and ecology; air pollution and global change; and biodiversity conservation. For more information, contact Dr. E. Paoletti; C.S. Patologia Specie Legnose Montane; CNR, Piazzale delle Cascine 28; I-50144 Firenze; Italy; phone 39-55-368918; e-mail: "raddi@cspslm.fi.cnr.it".

SEPTEMBER 28-OCTOBER 3 Istanbul, Turkey, is the venue for Ocean Pulse: A Critical Diagnosis–Our Global Oceans as Earth's Last Frontier and Door to the Past. This international conference will devote 3 days to examining three themes: how we can improve our harvests from the seas while preserving their sustainability into the next century; why historic shipwrecks should be excavated by archeologists; and what marine and biotechnologies will be required to better understand our oceans into the 21st century. Cosponsored by the Explorers Club and the Turkish government, the conference is being coordinated by Dr. John Loret, President Emeritus of the Explorers Club, and Dr. John Tanacredi, NPS Chief of Resource Management, Gateway National Recreation Area. A 12-day eco-tour of the Mediterranean is available following the conference. Conference cost is $2,168 including airfare from New York City; the eco-tour is an additional $2,895. Fax your registration to (212) 888-9819.

OCTOBER 19-21 The American Society of Landscape Architects will hold its annual meeting in Los Angeles. This exposition will focus on compelling evidence of landscape architecture work in planning, design, and technology that contributes to societal well-being. Contact Cheryl Wagner (Fax: 202-686-1001; e-mail: "cwagner@asla.org") for more information.

OCTOBER 25 Bandelier National Monument, Santa Fe National Forest, and the Los Alamos National Laboratory are co-hosting a no-fee Symposium of Biological Research in the Jemez Mountains, New Mexico, in Santa Fe. Contact Stephen Fettig ("stephen_fettig@nps.gov"; 505-672-3861, ext. 546), NPS Wildlife Biologist at Bandelier, by July 1 if you are interested in making a presentation; abstracts are due September 15.

DECEMBER 8-11 The 1996 Midwest Fish and Wildlife conference will take place in Omaha, Nebraska. Organized around the theme, "Sensible Management of Today's Altered Ecosystems," the gathering should interest ecosystem researchers, conservation biologists, and managers alike. Contact Jill Medland of the Great Plains System Support Office for further information at (402) 221-3994; e-mail: jill_medland@nps.gov.

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