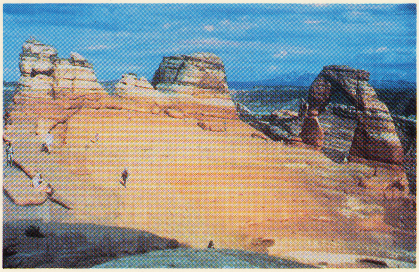
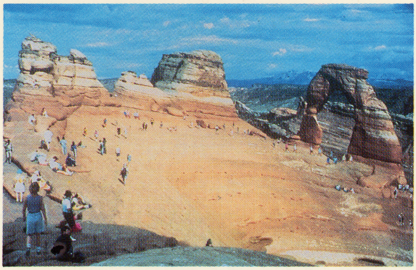
THE GEORGE WRIGHT

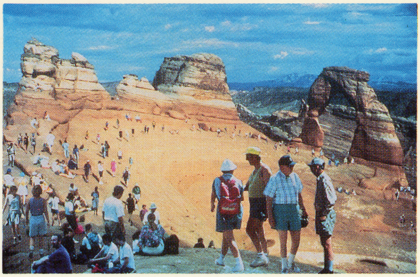
FORUM

A JOURNAL OF CULTURAL AND NATURAL PARKS AND RESERVES

VOLUME 12 1995 NUMBER 3







THE JOURNAL OF THE GEORGE WRIGHT SOCIETY

Dedicated to the Protection, Preservation and Management
of Cultural and Natural Parks and Reserves
Through Research and Education

The George Wright Society

The George Wright Society is a member of
US/ICOMOS (International Council on Monuments and Sites—U.S. Committee),
IUCN—The World Conservation Union, *and*
The Natural Resources Council of America

ISSN 0732-4715

Editorial guidelines may be found on the inside back cover.
The text paper of the FORUM is made of 50% recycled fibers.
Printing is by Weber & Sons, Park Falls, Wisconsin.

THE GEORGE WRIGHT FORUM

Volume 12 ❖ 1995 ❖ Number 3

On the Cover:

Computerized images of Delicate Arch in Arches National Park, Utah, showing hypothetical levels of crowding. These photographs were shown to visitors to gauge their acceptance of the differing levels as part of VERP, a new USNPS planning process. See article by Manning et al. starting on p. 41, and especially pp. 50-51.

Society News, Notes & Mail

SAMPAA II Proceedings Available

Ecosystem Monitoring and Protected Areas

Edited by Tom Herman, Soren Bondrup Nielsen, J. H. Martin Willison and Neil W. P. Munro. Published by the Science and Management of Protected Areas Association (SAMPAA). A collection of 72 papers presented at the Second International Conference in Halifax, May 1994. North American qnd international authors are presented. 590 pages, $45.00.

Marine Protected Areqs and Sustainable Fisheries

Edited by Nancy L. Shackell and J. H. Willison. A Series of 32 contemporary papers on the marine environment presented within the Marine Symposium at the Science and Management of Protected Areas Conference, in May 1994. 300 pages, $30.00.

Both volumes can be ordered for a price of $70 from:
The Science and Management of Protected Areas Association
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GWS in Touch with Congress on Historic Preservation, NBS, International Programs

The Society's Executive Office has spent a considerable amount of time since early June writing to Congress about legislation related to our areas of interest. These letters represent something of a departure for the GWS, which in the past has done little in the way of congressional contact. However, the Executive Office felt that the magnitude of some of the changes being proposed would have effectively crippled vital historic preservation and scientific research functions in the federal government, as well as a number of international environmental initiatives, and that action was therefore warranted on behalf of the GWS.

We are now tied into the US/ICOMOS e-mail list, and through it are able to respond to cultural-resource legislative alerts posted to the list. A series of campaigns were waged over the summer by preservation advocates to fend off draconian cuts and proposed eliminations of various federal programs. In June, we responded to a call for support of continued funding for the Advisory Council on Historic Preservation, emphasizing in our letter that "the Council is an extremely important entity in our country's historic preservation efforts" by virtue of "its capacity to coordinate disparate programs and to help ensure that the highest standards of professional conduct are applied to the preservation of our country's heritage...."

Also in June, in response to an alert from IUCN, we wrote to urge continued federal funding for a number of important international environmental programs, including the Convention on International Trade in Endangered Species (CITES), the Montreal Protocol Fund for CFC reduction, the World Heritage Fund, the Ramsar Convention on Wetlands, the Climate Change Convention, and IUCN itself, among others.

In July, we wrote to nearly 175 members of Congress to urge them to reject devastating cuts proposed for federal biological research, and the outright elimination of the National Biological Service. In this letter we argued that the U.S. public lands system is a "hallmark of American society," one of "the social institutions that defines us and binds us as a nation," and that it must be "held in trust for all time and managed by publicly accountable employees to the highest professional standards." To do this, we said, "our country needs a corps of federal employees doing biological research and management in the public interest, as that interest is defined and continually re-defined by the Congress and statutory authorities. Such research and management always has been, and should continue to be, done in partnership with colleagues from the private sector and the academic world. But this partnership must be anchored to the public interest, to a commitment to conserving our country's irreplaceable natural heritage in perpetuity."

In all, we made over 200 Congressional contacts on these issues. As we write (late August), the good news is that it appears the most radical cuts will not take place, though what is still on the table is far from acceptable. Since nothing has been decided yet, we expect further communications will be necessary in September as these issues go to Conference Committee and then to the President.

World Heritage Meeting Reviews Parks and Sites in Danger

Two important meetings related to the World Heritage Convention were held this summer. The first, held June 28-30 in Bergen, Norway, was the 2nd General Assembly of the parties to the Convention. It was followed by a meeting of the Bureau of the World Heritage Committee in Paris on July 3-8. A series of speakers at the General Assembly brought into focus various points of interest, emphasizing heritage conservation in cities that have World Heritage Sites. The Bureau meeting reviewed, among other things, state of properties on the list of the World Heritage in Danger. The only listed property which showed enough improvement to warrant consideration of being removed from the Danger List was Aïr-Ténéré National Nature Reserve (Niger), where a peace agreement was allowing management to move back into the park. There also was positive news from four other threatened parks. A refugee camp intended for Kahuzi-Biega National Park (Zaïre) has been relocated, and a new visitor center is being constructed with assistance from German authorities. In Manovo-Gounda St. Floris National Park (Central African Republic), despite unstable political conditions in 1993-94, a French company started a tourism venture, and it is hoped that this will bring needed revenue to the park. And both Lake Malawi National Park (Malawi) and Uluru-Kata Tjuta National Park (Australia) have received awards for park management.

Unfortunately, conditions in three other parks—Srebarna Reserve (Bulgaria), Sangay National Park (Ecuador), and Virunga National Park (Zaïre)—have deteriorated markedly. The meeting also discussed several letters the Bureau had received concerning the proposed plans to build a road through Redwood National Park (USA), but were pleased to report that these plans had been put on hold while the transportation agency sought an alternate route for the highway. A long discussion was devoted to the proposed New World Mine adjacent to Yellowstone National Park (USA), and the U.S. requested that IUCN and the World Heritage Center send a joint mission to the site. A spokesman for the Center noted that although the proposed mine was two miles outside of the park, the mine tailings site was in the Yellowstone watershed. He noted that the property was publicly owned by the State of Montana and the U.S. Forest Service, and the application of the Convention's provisions would allow USNPS to act outside the boundaries of the park in order to protect the ecosystem. As for cultural sites on the list of World Heritage in Danger, from Kotor (Yugoslavia), there had been no recent report, and the Center proposed to ask ICOMOS to undertake such a mission. Concerning the Royal Palaces of Abomey (Benin), in a response to a request by the Committee at its last session, the Center's spokesperson reported that a mission had left Paris for the site, proposing to develop a conservation plan and set up a permanent institutional structure to oversee the site. In Timbuktu (Mali), three mosques were the subject of a pilot project aimed at solving endemic conservation problems in earthen architecture in the city.

[This greatly abridged account is derived from e-mail reports sent from the

Paris and Bergen meetings by Peter H. Stott of ICOMOS. These reports, Stott noted, represents his observations and conclusions and not those of any organization.]

Announcement and First Call for Papers:

Conference on Coast Redwood Forest Ecology and Management

The coast redwood forest type is unique to California and extreme southwestern Oregon. Society values a broad spectrum of resources inherent in the coast redwood forest, including natural history, wood products, aesthetics, and a variety of plants and animals. However, the amount of published work on coast redwood has not matched the interest in its resources. The Conference on Coast Redwood Forest Ecology and Management, scheduled for June 18-20, 1996, at Humboldt State University, Arcata, California, will be the first of its kind for the region. In the plenary sessions, invited speakers will address the paleohistory of redwood, dynamic processes that influence redwood forests, the current status of the redwood type, wildlife, the human perspective, and the history of the redwood preservation movement. Contributed technical papers and posters will present the latest research; proceedings will be published shortly after the conference. The first two days of the conference will include plenary, concurrent, and poster sessions; the third day will be for field trips. Prospective participants should provide the program coordinator with a technical paper or poster abstract (250 words or fewer) by October 2, 1995. For more information, or to submit an abstract, contact the program coordinator: Ms. Kim Rodrigues, University of California Cooperative Extension, 5630 S. Broadway, Eureka, CA 95503; telephone 707-445-7351, fax 707-444-9334; e-mail: cdhumboldt@ucdavis.edu.

Steven H. Debenedetti

Society member Steve Debenedetti, the resource management specialist at Pinnacles National Monument in California, died at the age of 47 on August 11, 1995. A native of the Bay Area, Steve held undergraduate degrees from the University of California–Berkeley, and a Master's degree from Humboldt State University. He began his Park Service career at Yosemite in 1972, and subsequently served at Sequoia-Kings Canyon before moving to Pinnacles in 1984. He was a driving force behind several resource management projects at the park, including monitoring and mitigating rock climbing effects on wilderness areas, eradicating feral pigs, revegetating degraded areas, and monitoring air quality. He is survived by his wife, Jolene Wright, and daughter, Anna. Those wishing to make a donation in his memory should send a contribution to the American Cancer Society, 1715 South Bascom Avenue, Suite 100, Campbell, CA 95008, or to the National Park Foundation, 1101 17th Street, Northwest, Suite 1102, Washington, DC 20036-4704. In the case of the latter, please indicate if your donation should be earmarked for Pinnacles.

A Report from the North American Section of IUCN's Commission on National Parks and Protected Areas

Introduction

In this issue we begin a regular report of the activities of North American Section of IUCN's Commission on National Parks and Protected Areas (CNPPA-NA). For those who are unfamiliar with the CNPPA, it is a volunteer network of nearly 1,000 park professionals from around the world. CNPPA's mission is to promote "the establishment and effective management of a worldwide representative network of terrestrial and marine protected areas." Coming out of the last World Parks Congress in 1992, which was focused on sustainable development and protected areas, CNPPA's purposes were adjusted to reflect the role parks play in contributing to society. Thus, CNPPA "supports action by government agencies, international organizations, local communities, private land owners and non-governmental organizations to ensure that natural and semi-natural habitats can be conserved in such a way as to make their optimal contribution to human society." (Note that the CNPPA is concerned primarily with protected natural areas, in contrast to the GWS's emphasis on both natural and cultural sites.) CNPPA is one of several commissions of IUCN–The World Conservation Union, which was founded in 1948 and serves as an umbrella body for the world's conservation agencies and institutions. The CNPPA is served by IUCN's Programme on Protected Areas, headquartered in Switzerland.

The CNPPA network is divided into 15 geographical regions covering the world. In addition, there are networks for three specialized themes: Marine Protected Areas, Mountain Protected Areas, and World Heritage sites. Each region and the three themes are overseen by a CNPPA Vice-Chair. The Regional Vice-Chair for North America is Bruce Amos. Bruce is with Parks Canada at their headquarters just outside Ottawa. His address: c/o Commission on National Parks and Protected Areas, 25 Eddy Street, 4th Floor, Hull, Québec K1A 0M5, Canada; telephone: 819-994-2697, fax: 819-994-5140; e-mail: bruce_amos@pch.gc.ca. Over 20 GWS members are currently also members of CNPPA-NA.

This inaugural column of "News from CNPPA–North America" looks at recent activities of the Mountain Protected Areas (MtPA) theme network. The MtPA Vice-Chair, Larry Hamilton, is the author.

Mountain Theme Network

This theme was organized following a highly successful international consultation of 40 managers and researchers in the workshop "Parks, Peaks, and People," held in Hawai`i Volcanoes National Park in October 1991. This group formed the nucleus of an MtPA network that now includes roughly 160 individuals from every country with significant mountains. Forty of these people have American mailing addresses, although many of them carry out their field work overseas. Approximately one-half of the network are also members of CNPPA. The network is "nourished" by a modest quarterly newsletter, the *Mountain Protected Area UPDATE*. Any readers of *The George Wright Forum* who are working in mountain environments and would like to be members of this network would be welcomed. (Contact Larry Hamilton at the address below.) A survey of members this year indicated that 90% preferred *UPDATE* in hard copy, and that is what will prevail.

Agenda 21 for Mountains

The chief activity of the theme is to bring the protected area dimension to the international process of implementing the mountain chapter of Agenda 21, the global plan which emerged from the 1992 Earth Summit in Rio de Janeiro. This chapter, entitled "Managing Fragile Ecosystems: Sustainable Mountain Development," gave recognition, for the first time in the international political arena, to the special qualities of these three-dimensional Earth features, with their marginalized mountain inhabitants—qualities that require a different type of treatment than that applied to the populous "flatlands." The theme is part of a key International Interagency Network on Mountains which is working with the Food and Agriculture Organization of the United Nations in mapping out implementation strategies. One of the events organized was a worldwide NGO meeting held in late February 1995 in Lima, Peru, to gather and subsequently present NGO views to the April 1995 meeting of the U.N. Commission on Sustainable Development. Organized by The Mountain Institute of Franklin, West Virginia, the Lima meeting was co-sponsored by IUCN. Two months later, in the Bolivian Altiplano, mountain network members and the MtPA theme helped organize and carry out an Andean Sustainable Development Symposium. This meeting formally launched an Andean Mountain Association of researchers and managers. A series of regional intergovernmental mountain conferences is called for as part of the political awareness-raising process of the Mountain Agenda. Two of these have taken place, one for Asia in Kathmandu, Nepal, in December 1994, and one for South America in Lima in July 1995. The European meetings are scheduled for May 1996 in Scotland and September 1996 in Trento, Italy. Planning is underway in Africa, and we hope that North America will start to get its act together. In all of these, MtPA network members are playing substantial roles.

Transboundary Workshop Coming

Looming on the horizon is a workshop on Mountain Transfrontier Protected Areas (co-organized by the MtPA theme) to be held in the Australian Alps, November 12-21, 1995. Approximately 30 participants from 17 countries will exchange experiences in transboundary cooperation (or frustration), and learn from the remarkable degree of success being achieved in cooperative management of seven different parks or reserves in two independent Australian states and the Australian Capital Territory. It is hoped that the Glacier–Waterton and Kluane–Wrangell St. Elias–Glacier Bay transfrontier units will be participating.

The Global High Mountain Protected System

Based on tough criteria (a minimum size of 10,000 ha, minimum relief difference of 1,500 m, and classification within IUCN Protected Areas Categories I-IV), a global inventory [J.T. Thorsell and J. Harrison, "National parks and nature reserves in mountain environments and development," *GeoJournal* 27(1): 113-126 (1993)] revealed at least 442 mountain protected areas worldwide, covering some 243 million ha, based on data available at the World Conservation Monitoring Centre. Obviously many more areas of smaller size, lower elevational difference, and in IUCN's Protected Landscape or Managed Resource Protected Area categories are acknowledged by the public (and claimed by their managers) as mountain protected areas, and would substantially increase these numbers. Has the minimum relief been lowered to 1,000 m, another 200 sites would have been added.

Cordillera Corridors

It is the task of the CNPPA MtPA theme to promote better management of these and other mountain protected areas, identify gaps in the mountain system of parks and reserves, and work for the establishment of new protected areas of all types. Special attention is currently being given to transfrontier cooperative management, and to promoting cordillera-length corridors of linked mountain protected areas. In the latter case, the concept of a Protected Conservation Corridor of the Americas, extending from Tierra del Fuego to Beringia utilizing the main mountain ranges, is being advanced. Many elements are in place as a foundation. It is of interest to note that two NGOs, the Canadian Parks and Wilderness Society and American Wildlands, have already begun to map critical corridors from the Northern Canadian Rockies down to Greater Yellowstone. CNPPA–North America supports this approach.

CNPPA Gathering in Banff

There will be a get-together of the MtPA theme "members and adherents" at the North American CNPPA Regional Meeting in Banff National Park, October 14-19, 1995. Persons coming to this meeting and having an interest in mountains are urged to join the gathering.

MtPA Contact

For more information on the MtPA network, contact Professor Lawrence S. Hamilton, Islands and Highlands Environmental Consultancy, R.R. #1, Box 1685A, Hinesburg, Vermont 05461 USA; telephone and fax: 802-425-6509.

George H. Stankey

The Pursuit of Sustainability:

Joining Science and Public Choice

The publication of *Our Common Future* (the "Brundtland Report," WCED 1987) brought an unprecedented level of both scientific and popular attention to the concept of sustainability. Defined as the ability to meet the needs of the present without compromising the ability of future generations to meet their own needs (WCED 1987), sustainability seemingly offered an objective basis upon which a global society pondering environmental problems such as desertification, tropical deforestation, and global warming could make decisions.

The enthusiasm surrounding sustainability as the keystone of future society–environmental relationships is not surprising. First, it is a politically attractive idea because it offers an alternative to the kinds of absolute limits suggested, for example, by Meadows et al. (1972). It suggests that we can "have our cake and eat it too." Second, it is a familiar concept to natural resource professionals. Forestry, fisheries, and wildlife managers have long dealt with corollaries of sustainability, such as sustained-yield forestry (Steen 1984), maximum sustainable yield (MSY) fisheries (Holt and Talbot 1978), and wildlife carrying capacity (Dasmann 1964).

Today, however, nearly a decade after the publication of the Brundtland report, the pursuit of strategies and policies for a sustainable future seems frustrating. For an idea that seemingly embodies such a fundamentally logical proposition, sustainability remains frustratingly elusive.

In this paper, I examine three ideas about sustainability that require attention if our pursuit is to be successful. First, although sustainability embraces complex scientific issues and questions, at its root, it is fundamentally a philosophical construct. Second, if sustainability, however defined, is to be achieved, it must involve an informed dialogue between citizens and scientists. Third, successful implementation of sustainability requires major institutional reform.

Sustainability: Science or Myth?

In 1991, the New Zealand Parliament passed the Resource Management Act (RMA). The basic purpose of the RMA is to promote a more rational, integrated, and *sustainable* approach (emphasis added) to natural resource planning and management. The criterion of sustainability aims to manage resources to provide for social, economic, and cultural well-being while sustaining the potential of resources to meet future human needs, safeguard life-supporting capacity, and protect against adverse environmental effects.

These are noble aspirations, but they inspire more questions than answers. The concept of sustainability seems rooted in science, capable of technically precise definition, yet its use in the RMA example suggests it plays a different role. Rather than a scientific or technical notion, sustainability represents a philosophical idea or a *myth.* Sustainability as myth is not a pejorative characterization, but rather acknowledges that it is a way in which society attempts to find order and purpose in the world. De Neufville and Barton (1987:181) explain that myths are "important to the definition of problems because they link public issues to widely accepted ways of understanding the world and to shared moral evaluations of conditions, events, and possible solutions to problems."

For example, the language of the RMA calls for "social, cultural, and economic well-being," a concern for future generations, and support for nature protection. These are clearly purposes for which wide social support and concern exist and, indeed, one of the central values of myths is that they constitute powerful means of communicating to the public and motivating their support (Murray and Swaffield 1994).

But myths also have a downside. They conceal crucial contradictions and realities, which, if not recognized, can confound efforts to implement action. Myths also create support for the status quo and promote unrealistic or inaccurate perceptions of needed policies and programs (De Neufville and Barton 1987). We can see such problems with regard to sustainability. For instance, the simultaneous concern for the present and the future expressed in the Brundtland Commission's definition of sustainability implies a complex balancing of equity considerations between, as well as within, generations. It masks formidable questions of the appropriate scale of spatial analysis, and it obscures the complex intervention that technological change might play.

None of the above should be interpreted as suggesting that sustainability is not important or that scientific understanding is not needed. Rather, it is an argument for recognizing that sustainability is fundamentally a sociopolitical construct rather than a scientific concept capable of precise, unequivocal measurement. It reflects a state to which we aspire, it embodies a concern with our ability to exist as a species, and it opens the door for scientists and technical specialists to engage society in an issue of mutual concern. The nature of this engagement brings me to my second point.

Scientists and Citizens Must Join Discussions About Sustainability

The debate about sustainability must move beyond the pages of our technical journals and our academic halls. Scientists and resource management specialists need to aggressively encourage and facilitate broad public discourse on the subject.

Much is at stake. If the arena of discussion does not expand, the resulting isolation of sustainability as a "scientific" concern will be fatal, both politically and substantively. In addition to informing society of the scientific dimensions of sustainability, public discourse must occur to gain political understanding of, and support for, needed policies and programs, to tap public knowledge, and to facilitate the public scrutiny requisite for defining and implementing such an idea.

Public discussions involving citizens and scientists about sustainability are necessary not only to promote understanding of scientific and technical factors (e.g., biophysical constraints, processes, and functions), but also because, ultimately, sustainability involves *social* choices about what, for whom, and at what costs. Depending upon these choices—the mix of goods and services we seek from nature, the kinds of technologies we are able and willing to adopt, and the kinds of rules with which we choose to live—there are many possible sustainable options.

For example, Gale and Cordray (1991) ask the rhetorical question, What should forests sustain? In response, they identify eight conceptually distinct, though not mutually exclusive, answers, including "dominant product sustainability" (production of a desired level and mix of particular forest products), "community stability" (focus on the needs of human systems dependent upon a flow of goods and services from the forest ecosystem), and "global village sustainability" (a focus on the role of a local system or set of outputs in the global context). With each definition, the nature of the outputs and the recipients, character, and location of the costs and benefits changes, as does the definition of sustainability.

Because choices exist, the formulation of sustainable development strategies must occur in a political arena in which the values and concerns of society are integrated with the biophysical, ecological, and technical aspects of science and planning. However, because of the dominance of the scientific–rational model of planning (Wondolleck 1988), sustainability has tended to be conceived of primarily as a technical problem requiring a technical solution. Yet there is growing evidence of the limits of such an approach to problems involving an array of equity, distributional, and social justice issues in addition to their technical aspects (Allen and Gould 1986). As *Our Common Future* notes:

> ...[S]ustainability cannot be secured unless development policies pay attention to such considera-

tions as changes in access to resources and in the distribution of costs and benefits. Even the narrow notion of physical sustainability implies a concern for social equity between generations, a concern that must logically be extended to equity within each generation (WCED 1987:143).

Thus, the debate about the kind of sustainable society that we want must satisfy several criteria. Given the complexity and uncertainty that characterize the choices before society, the debate must be *informed;* that is, it must provide an understanding of this complexity, of probabilities, of cause and effect, and of consequences and implications. It also should be *deliberative;* that is, it should proceed at a pace that offers opportunity for mutual learning and reflective thinking. Finally, it should be *discursive;* that is, it should encourage interaction among the various stakeholders, such as scientists, policy makers, and citizens who represent a full range of interests.

But where in our society do such thoughtful discussions occur? Unfortunately, many possible candidates (e.g., public involvement meetings) engender virtually the opposite qualities: they foster discord, promote strategic behavior, and confuse rather than inform. Generally, they exacerbate conflict rather than promote the search for solutions.

This need not be the case. In his book *Coming to Public Judgment: Making Democracy Work in a Complex World,* Yankelovich (1991) addresses the problem in the following way. In discussions of serious issues facing society, how do we move from *opinion*—those stances we all hold about the world around us, but often only superficially and with little understanding—and *judgment*—the positions we taken when we grasp the consequences associated with our view? He suggests a three-step framework to consider this question. First, it is necessary that public consciousness be raised; simply, people must be aware that the issue exists. Generally, the media plays a major role in doing this. Step 2 involves the thoughtful deliberation of the problem—its causes, possible solutions, potential consequences and implications, etc. Finally, Step 3 is resolution: we come to a conclusion and act upon it. In our society, we have an array of instruments, such as laws and policies, to promote resolution.

Step 2—what Yankelovich refers to as "working through"—is crucial to the operation of this process. This is the point at which we begin to engage the complexity embodied in the issue. For example, when we begin to work through the idea of sustainability, the kinds of problems that the myth of sustainability can obscure (e.g., the tension between inter- and intragenerational equity) become apparent. It is here that we confront the reality that we face difficult choices and that all our actions (including no action) involve consequences.

Many factors militate against the

formation of public judgments as defined by Yankelovich. For instance, the ambiguity of scientific assessments as to what constitutes sustainable practices can lead to confusion; different views by different experts lead to different conclusions. Spatial and time frames are measured in decades, yet the relevant scale for sustainability issues might be centuries (Allen and Starr 1982).

One source of opposition to an enhanced role for the public in the search for appropriate policies for sustainability comes from scientific and technical interests. In extreme cases, some might view such dialogue as an abdication of science altogether, leaving decisions to popular opinion. But experience suggests such dialogue can inform public understanding, even where substantial complexity exists; it enhances, rather than diminishes, expert status (Yankelovich 1991); and that public scrutiny contributes to, rather than detracts from, rigorous and defensible technical analyses (Paehlke and Torgerson 1990).

Because many aspects of sustainability are technically complex, scientists have a responsibility to inform society of the options, consequences, and implications that must be considered in making social choices. There is also the need to invite citizens to contribute their knowledge to these deliberations; the personal or "experiential" knowledge held by people who have lived, worked, and played in the environmental settings with which we are concerned are often rich in detail and insight, and can be an important complement to scientific understanding (Friedmann 1987). Rather than diluting the debate or leaving the choice process to some kind of simple "majority rules" vote, such interaction can increase, rather than reduce, the likelihood that scientific understanding will be incorporated into the choices that society eventually makes.

However, the most significant barrier to working through is simply the lack of forums where such a process can occur. As Yankelovich notes (1991:65), "Our society is not well equipped with the institutions or knowledge it needs to expedite working through." Yet the development of such forums that facilitate discourse among public interests and between the public and technical specialists is essential to solving "the quandary"; that is, "How can the democratic ideal of public control be made consistent with the realities of a society dominated by technically complex policy questions?" (Pierce and Lovrich 1983:1). This brings me to my last point.

Sustainability Challenges Existing Institutions

One outgrowth of the interest in sustainability has been increased attention to the concept of ecosystem management. Although the definition of ecosystem management is arguable, most observers agree that it implies significant changes in the way natural resource management is conducted; e.g., larger spatial and longer time scales, an integrated approach to planning and management, and an increased focus on processes and functions rather than inputs (Slocombe 1993; Grumbine 1994). However, an important point of agreement in the literature is that the lack of effective institutions is a major constraint on the successful implementation of ecosystem management (Stockdale 1989). It is an observation applicable to sustainability as well.

Institutions include the formal and informal rules, behaviors, and structures that govern society's behavior. Thus, institutions include formal structures, such as laws and policies, as well as informal customs, practices, and norms of behavior. For example, customs and practices affect how we think of, and organize ourselves around, such functional areas as timber, wildlife, or recreation (Cortner et al. 1995).

While some might think of institutions as vague, amorphous entities, their influence can be profound. For example, Wilkinson (1992) describes certain institutions of natural resources management in the United States, such as the 1872 Mining Law, as "the lords of yesterday": powerful structures and strictures formulated a century ago, but whose influences persist. Today, however, their influence, logic, and appropriateness must be questioned.

Successful implementation of sustainable practices and programs will require fundamental reform in the institutions of natural resource management. There is increasing criticism of the hierarchical, formal, and centralized structures upon which modern natural resource management rest. There is growing criticism of the ability of existing institutions to conduct the kind of critical self-analysis required to change in the ways needed. But such criticisms beg the more fundamental question: Change in what ways? Here are some thoughts about the nature of institutions required to facilitate sustainability, drawn from Paehlke and Torgerson (1990).

First, they need to be *non-compartmentalized.* This means that they reject the highly functionally based, isolated structures we find commonly today in favor of structures that facilitate complex analyses involving differing functional areas (e.g., fisheries and forestry). Second, they are *open* and thus promote a broadened scale and scope of decision making, replacing the secretive, cloistered processes of yesterday with increased public scrutiny. Third, they are *decentralized* in order to promote rapid, informed action at the local level. Fourth, they are *anti-technocratic.* This does not imply a rejection of technical expertise, but rather a recasting of its role, changing from one that dictates to one that informs. Fifth, they are *flexible.* Flexible organizations reject universal, standardized structures and processes for those responsive to particular conditions and circumstances. The growing interest in adaptive management (Lee 1993) reflects such a concern.

Conclusion

Formulating appropriate policies for sustainability is a major challenge confronting society. It is essential that the technological and scientific discussions be supplemented by an increased effort to state the problem in social terms. The central question today is, What is our vision for the future?, and, as a corollary, What are the implications of a given decision in light of both ecological principles and equity and social justice considerations? In order to address effectively such questions, new processes, institutions, and structures are required to mesh science with informed community judgments. Without such a development, it seems unlikely that the goal of *Our Common Future* can be achieved: "to further the common understanding and common spirit of responsibility so clearly needed in a divided world" (WCED 1987:xv).

This paper is based on a keynote presentation at the biennial meeting of The George Wright Society, the 8th Conference on Research and Resource Management in Parks and on Public Lands, Portland, Oregon, April 17-21, 1995. It is derived from a paper presented by the author, along with Roger Clark and Peter Cullen, entitled "The Social Foundations of Sustainability: Implications for Resource Management Institutions," at the Centennial Meeting of the International Union of Forestry Research Organizations, Berlin, Germany, 31 August-4 September 1992. This work has been supported by the People and Natural Resources Program, Pacific Northwest Research Station, USDA Forest Service, Seattle, Washington, and by The Consortium for the Social Values of Natural Resources.

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Dealing With In-Park Controversy Surrounding Resources Management Actions:

A Case Study of the Island Fox Monitoring Program at Channel Islands National Park

As resource managers or scientists in protected areas, we sometimes assume that our actions, be they research, monitoring, or mitigation, are not only the best course of action but are also supported, if not applauded, by other park staff. This is not always the case, though, and when our actions or intended actions generate controversy among the staff, the results can be divisive.

At Channel Islands National Park, vocal opposition by a handful of staff members very nearly halted a rather innocuous population monitoring program for island fox *(Urocyon littoralis)*. In the end, an environmental assessment (EA) for the proposed action was the instrument by which the program was evaluated, and was also the decision-making process which ultimately allowed the fox monitoring program to be implemented. Unanimous staff support for the project was never truly gained, though direct opposition to the project was tempered by the objectivity of the EA process, and by increased communication and flexibility on the part of our resources management staff. For us, the staff reaction was a wake-up call, and the island fox monitoring program has become a case study in how staff perceptions can influence implementation of a project.

The Biological Monitoring Program at Channel Islands National Park

Channel Islands is one of several units chosen as prototype parks for the USNPS inventory and monitoring program. Accordingly, the park has developed a comprehensive biological monitoring program for both marine and terrestrial ecosystems. Due to imminent threats to marine resources, the marine component was developed first, prior to the park's selection for the national program. The terrestrial protocols, including the one for island fox, were developed later. The design study for island fox and other terrestrial vertebrates was begun in 1985, and the final protocol was published as a handbook in 1988. However, the park was unable to hire permanent staff to implement the terrestrial protocols until 1992, when the bulk of the servicewide funding came through. Consequently, the protocol sat on the shelf for five years before park staff made plans to implement it in 1993.

The island fox was a logical choice for monitoring. A diminutive relative of the mainland gray fox *(Urocyon cineroargenteus)*, the island fox is found on the six largest of California's eight Channel Islands. Though individuals weigh less than 4 kg, the fox is the largest native mammal on the islands. Due to its small population size on several islands, the fox has been listed as threatened by the state of California and is a Category 2 candidate species for the federal list of threatened and endangered species. The island fox was chosen as a key species to monitor at the park because of its state-listed status, its apparently low population, the general lack of demographic information about this species, and the relatively high amount of public interest in this unique canid.

The fox monitoring protocol uses standard capture–mark–recapture techniques to generate estimates of island fox population densities on San Miguel Island. The protocol, as written, called for fox to be captured using box-type traps on large grids, with animals permanently marked with thick cable-tie collars. Prior to the protocol's implementation in 1993, park staff made several changes to it in order to take advantage of new technology, and to bring the park's program in line with island fox monitoring programs being conducted outside the park. These changes included increasing the number of traps and decreasing the distance between traps, shifting the trapping season from winter to mid-summer, and changing the marking method to colored ear-tags, while experimenting with the use of passive-integrated transponder (PIT) tags.

Objections to the Monitoring Program by Park Staff

In early 1993, the terrestrial monitoring staff announced plans to conduct summer fox monitoring field work on San Miguel Island. At the same time, the park had received matching cost-share funding to support doctoral dissertation work regarding island fox genetics and ecology on Santa Rosa Island, with the ultimate intent of conducting a population viability analysis for the species. However, as the monitoring staff prepared for summer field work, it became apparent that the project did not enjoy unanimous support from other park staff. A handful of park staff, including some members of the management team, objected vehemently to a live-trapping program for island fox, this despite a three-year design study funded by USNPS and previous review and approval of the published protocol by park management. The objections focused on three assumptions:

- Live-trapping and marking would adversely affect island fox individuals and populations;

- Previous fox research on San Miguel had made the foxes on that island skittish and wary of humans, unlike "friendlier" foxes on other islands; and
- Island foxes were doing fine, and did not need to be monitored.

We were surprised, even blindsided, by the vocal opposition we encountered. It became apparent that the objections were, in part, the outward manifestations of the following larger issues that lurked beneath the surface.

Charismatic megafauna and the effect of scale. The Channel Islands lack large native carnivores and ungulates, so the undeniably cute island fox is the recipient of paternalistic and protective feelings commonly directed toward larger heroic species. For many park staff, as well as visitors, the island fox has come to symbolize the uniqueness of the Channel Islands, and, consequently, the species seems to carry special rank. People feel especially protective of it. Thus, to some, capture and marking of pinnipeds on San Miguel by National Marine Fisheries Service biologists is an acceptable research methodology, but live-trapping and marking island fox is not.

Benign neglect and the mistrust of science. We were surprised to discover an attitude among some park staff that island foxes were obviously doing fine, and did not need to be studied, monitored, or managed, and that further study would be detrimental to the species. Here, then, was an undercurrent of anti-intellectualism manifested in a mistrust of science in general, and resources management in particular. For those of us who were weaned on the findings of the Leopold Commission, this was a reminder that not all USNPS employees view good data as a prerequisite for making informed management decisions regarding park resources.

Aesthetics. Some staff felt that the visitor experience on San Miguel Island would be diminished by viewing fox with obvious identification marks, such as colored ear tags.

Oral tradition and the sins of the past. The cable-tie collars used as permanent markers in the original design study had caused the death of one fox, before the collar design was improved. Though eight years had passed, we discovered an oral tradition handed down among San Miguel Island staff held that the negative past trapping experiences had made San Miguel Island fox skittish and wary of humans, and that more research was the last thing the fox population needed.

Interdivisional friction. Being the new kid on the block, with a recent base-funding increase for the monitoring program, the resources management division has been the target of some resentment from other staff divisions that have not fared so well. This accounted for some of the vitriol directed toward the proposed fox monitoring.

Political pressure. The grazing permittee on Santa Rosa Island objected strenuously to the proposed live-trapping, marking, and blood-sampling of fox on that island, terming the methods "cruel" and "inhumane." While on the surface this may not appear sufficient to sink a program, in this case the permittee pulls considerable weight politically, and the park carefully chooses the battles it wishes to fight with it. As it turned out, park management chose not to pursue fox research on Santa Rosa.

Canis envy. Resources management staff coined this phrase to describe the resentment directed toward the field personnel who would be allowed to handle the foxes.

NEPA as an Evaluative Tool and Decision-making Process

Faced with in-park controversy regarding the proposed monitoring, park management directed that an environmental assessment be prepared covering both the research and monitoring. This may be viewed as a somewhat biased application of the National Environmental Policy Act (NEPA), since most other resource management activities and all monitoring programs had been assumed to be covered under the umbrella NEPA compliance performed on the park's general management plan and resources management plan. Moreover, the departmental categorical exclusion for non-destructive data collection (Part 516, Department of the Interior Manual, Section 2, Appendix 1.6) may have applied to the proposed fox monitoring, though the departmental exception regarding controversial environmental effects (Part 516, Section 2.3A(3)(c)) may also have been applicable.

However, as well as being a vehicle for environmental compliance, an environmental assessment can also be used as a decision-making mechanism. We found the objectivity inherent in the environmental assessment process to be of great value in evaluating the worthiness for monitoring and in determining probable effects of the monitoring on island fox.

The environmental assessment focused on several key questions. First, was fox monitoring necessary? That is, would it provide park management with data useful, if not required, for managing park resources? Second, would proposed fox monitoring methods negatively affect fox populations or individuals, or were there other less-intrusive methods that would be acceptable?

For the EA we interviewed all researchers who had ever worked on island fox to determine effects on individuals and populations. We found that the incidence of injury and mortality caused by traps was extremely low for the box-type procedure. Dental injury (broken teeth and bleeding gums) had occurred occasionally before it became standard procedure to add polyvinyl chloride (PVC) "chew bars" to traps. Known mortality was limited to the one collar-caused death during the design phase of the San Miguel study, and one animal that had died from hypothermia on Santa Catalina Island. No researchers found a change over time in fox response to trapping: some individuals were trap-happy, some were trap-shy, and these proportions did not change significantly over the course of the studies. Trapping did not appear to be an adverse experience for the fox, as evidenced by the high rate of recaptures for island fox studies. Neither individuals or populations appeared to be affected by fox monitoring methods.

There was also consensus among researchers that grid trapping and capture-mark-recapture were the only viable population monitoring methods for island fox, and that other methods, such as observation of sign or crude counts, were not tenable.

The EA also put to rest doubts about the value of monitoring data. The information to be gained from the research and a long-term population monitoring program is crucial if the USNPS is to insure the long-term viability of island fox populations under its management authority. Small, isolated populations such as those of the island fox are subject to quick demographic changes that can be brought about by environmental or human-caused factors. For example, if a population decline were to be caused by introduction of a canine disease, fox populations could become locally extirpated before a change was detected and well before any management actions could be taken. Establishment of a long-term population monitoring program will allow USNPS managers timely access to data on population trend and causal factors upon which management decisions can be based.

The finding of no significant impact and record of decision cited the preponderance of evidence supporting a monitoring program for island fox. This was moderated by a concession to the grazing permittee that fox monitoring would not be implemented on Santa Rosa Island, though the USNPS reserved the right to do so in the future.

The Need for Communication and Flexibility

Though we saw the park decision as a victory for rational thought, intellectualism, and the scientific method, park staff support for the project was still not unanimous. And while we regretted that some were not as swayed by the evidence as we were, we respected the diversity of opinions on the subject (though one of our staff was heard to grumble, "We don't tell them how to do law enforcement or maintenance, so why should they be able to tell us how to monitor?"). Suffice it to say that it is heartening that staff who are not resources managers care deeply about the resource.

We realized that we had a long way to go in convincing park staff of the need for comprehensive monitoring of sensitive park resources such as the island fox. We had, indeed, failed to communicate adequately the potential threats to island fox and the need for long-term monitoring information. Ecological principles, resource management goals, research, monitoring, and mitigation are the everyday concepts that we biologists take for granted, but they can be as foreign as rocket science to park staff members who haven't had those ideas drilled into their head through experience or education. While most people can see that clean facilities and a safe environment are necessities for visitors, it takes a little time to digest concepts such as population viability analysis, or local population extirpation through stochastic processes.

And not wanting to be bad winners, we were more than happy to concede several points that were still bones of contention for some park staff. For example, monitoring staff stepped up the conversion of fox marking methods from colored ear tags to PIT tags. We had planned to use PIT tags exclusively as soon as we could test their efficacy. The tags are no bigger than a grain of rice and are injected subcutaneously (Figure 1), where they stay for the life of the animal as an imperceptible but permanent mark. Hence, no more unsightly colored markers on otherwise wild animals. Second, we left a portion of San Miguel unsampled, so there would be a population of foxes which had never been trapped. Finally, we reduced the number of permanent grid markers on San Miguel to one per grid, to decrease the number of rebar stakes in natural settings.

Figure 1. USNPS monitoring staff insert a passive integrated transponder (PIT) tag into an island fox on San Miguel Island.

From our standpoint, the program to date has been very successful. Two years of field data have generated good density estimates with tight confidence intervals, as well as solid data on recruitment and age/sex ratios. Moreover, we have trapped some of the original collared animals from the design study phase. These foxes were first trapped during the period 1985-88 and so are at least 7-10 years old by now. This new data extends the known longevity for island fox by several years.

We must remind ourselves, as well as others, that these short-term results are not the reason we are pursuing this monitoring so aggressively. The litmus test of the fox monitoring program, as for the rest of the long-term ecological monitoring programs in USNPS, is whether the data, in the long run, are relevant to management decisions. It is thus crucial to build a constituency among park staff for monitoring and other research and resources management activities. For if we cannot convince park staff of the worthiness of informed decision-making, how can we expect a skeptical public to embrace it?

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Visualization in Decision-Support Systems:

A Proposal for the New River Gorge National River

Introduction

The New River Gorge National River (NRGNR) faces a problem common to most protected areas: its integrity is dependent on the mutual understanding and collaboration of multiple stake-holders within and around the area. Collaborative decision-making has been declared essential to realizing sustainable ecosystem management. In addition to requiring innovation in physical techniques, ecosystem management requires innovation in the human dimensions of protected areas management. Learning and communication are the basis of that collaboration. People must have a shared understanding and be able to communicate clearly about the resources and issues in order to make decisions and reach agreement. Information systems that aid solving complex problems by augmenting the user's knowledge are called *decision-support systems* (DSS's). Supporting learning and communication are basic functions of a DSS. Visualization can be applied to meet these learning and communication needs. Visualization is the use of representations to aid visual thinking and visual communication, a mode that is particularly suitable for ecosystem information. Maps, images, diagrams and graphs are typical representations used to aid thinking about an ecosystem. This paper presents a concept for a DSS for the NRGNR, and suggests visualization applications for the proposed Land Management System of the New River Parkway. The paper concludes with a brief discussion of the problems and potentials of implementing such a system.

Decision-making Needs In Ecosystem Management

Case of the New River Gorge National River

The New River Gorge National River of West Virginia provides a rich mix of natural and cultural resources, as well as recreational attractions. The integrity of these resources depends on the cooperation of many stake-holders. The National River is located in the lower reaches of the New River Basin amidst a complex pattern of ecosystems, land uses, and ownership. The New River passes through two mountain chains, three states, and several counties before cutting into the Allegheny Plateau to form the gorge below the town of Hinton. River flows up to this point are regulated by two major dams, one managed by an electrical utility, and the second, just above Hinton, by the Army Corps of Engineers. Wetlands, fish, and wildlife are regulated by both federal and state agencies. The water quality of the river is largely determined by land uses in the river basin, which are minimally regulated by various local governments of three states. Development in the gateway communities around the National River occurs without the guidance of land-use regulations. To protect those resources occurring on the private land, the U.S. National Park Service (USNPS) relies on monitoring of resources and cooperative agreements on management, and also provides technical assistance on management (USNPS 1982). The proposed New River Parkway would implement a Land Management System, administered by the local governments, to guide land use on the private land within the parkway corridor. For National River lands managers must ultimately rely on the cooperation of the users to avoid conflicts and mitigate recreational impacts. Communication and interpretation are typical methods of managing user behavior. For this protected area, as in most, users, neighboring land owners, managers, and officials are all actors in resource decision-making.

The Context of Ecosystem Management

The problems facing the NRGNR are examples of problems basic to sustainable ecosystem management. The ecosystem approach has been proposed as a new paradigm in environmental management for protected and multiple-use natural areas (Agee and Johnson 1988), and even human settlements (Lyle 1985). Increasing appropriation of natural resources and evidence of global environmental change has raised concerns about the sustainability of trends in natural resource use. The goal of ecosystem management is to maintain the health of the ecosystem while providing for sustainable human use. Current scientific thought suggests that ecosystems are more complex, dynamic, interrelated, and extensive than we have been managing for; this implies the need for major innovations in natural resource management (Slocombe 1993). Ecosystem approaches stress the need for the integrated management of multiple resources over larger areas and longer time frames than presently attempted. The complexity of such management exceeds the capacity of current science to propose management strategies with predictable results, suggesting that an adaptive experimental management approach is called for (Kessler et al. 1992).

The question for environmental scientists is how to expand interdisciplinary collaboration to build a more comprehensive science. For public agencies, the scale of ecosystem management implies the need to coordinate their activities to effectively manage shared resources (Agee and Johnson 1988). Public support for such extensive management, which may also include private lands, must be developed through more participatory planning processes (Slocombe 1993). These contemporary issues of ecosystem management are in many ways simply expansions of perennial issues in protected areas management. To preserve the natural heritage of a place and to build societal appreciation and support for that heritage is central to the mission of U.S. national parks.

Learning and Communication Needs in Ecosystem Management

For this discussion we will consider ecosystem management as consisting of two major processes: the *technical* and the *social.* The technical process involves the science and method of analyzing and manipulating the physical components of the ecosystem. The social process involves the steps in decision-making that guide implementation of the technology. Social processes include promoting public awareness, developing consensus on policy goals and management actions, and cooperating in implementation. In this paper we focus on two basic human processes fundamental to decision-making—learning and communication.

The complexity of ecosystems and the increasing complexity of their management suggest that society ought to learn more about ecosystems. Learning can be defined simply as the assimilation of information within a person. Two characteristics of ecosystems relevant to learning are *complexity* and *interrelatedness.* Complexity results from the multi-dimensional and dynamic nature of ecosystems. The implication of complexity is the difficulty of comprehension and the uncertainty of analysis and prediction. Interrelatedness of ecosystem components and processes call for holistic approaches to understanding ecosystems. The following are some general ecosystem learning needs:

- To increase knowledge of ecosystems and their management across society in order to develop societal appreciation and support.
- To increase understanding among the scientific disciplines in order to develop integrative concepts and methods for management.
- To increase understanding among the scientists and the managers in order to develop effective and practical methods.
- To increase understanding among stake-holders—all interested parties—in order to develop appreciation of each other's interests and find areas of agreement.

Both the Park Service and its advocates have noted the importance of the educational role for the agency. The USNPS has stated the importance of education and communication outreach to building supportive constituencies and partnerships for resource protection (USNPS 1992). Further, it has been suggested that the educational role of national parks be strengthened to develop public understanding and motivation to deal with large-scale environmental problems (NPCA 1989).

Learning about ecosystems requires the ability to communicate about them. Additionally, to collaborate in ecosystem management, citizens, managers, and scientists need to be able to communicate clearly with each other. Communication can be defined simply as the transfer of information among people. The complexity of ecosystems makes communication challenging, particularly across differences of expertise. The novelty of ecosystem management also increases the difficulty of communication. It is difficult to talk about things that are not yet part of a shared experience and language. The following are some general ecosystem communication needs:

- Scientists and managers must be able to communicate with each other about research findings and needs, as well as about the newly discovered values of the resources and innovations in management.
- Scientists must be able to communicate with each other across domains of knowledge.
- Managers must be able to communicate with each other across resource specializations and among agencies.
- Citizens must able to communicate with managers and other stake-holders about their values for the resources.

As with learning, the public agencies have a central role in facilitating the communication among stakeholders in ecosystem management. In the following discussion we will outline characteristics of an information system that addresses ecosystem learning and communication.

Decision-Support Systems

The technical and social processes of ecosystem management involve different types of decision-making, which in turn benefit from different types of support from information systems. Technical decisions, such as those which occur in operational management, have agreed-upon objectives, and tend to be quantifiable, predictable, and have established solutions. These types of decisions are amenable to analytical computing to find optimum solutions. Social decisions, such as those which occur in policy development and management planning, typically include technical issues (though often in interrelated sets), but center on subjective issues such as goals and evaluation. Social decisions cannot be automated, and they ultimately require the exercise of human judgment. Also, in ecosystem management technical decisions may have high degrees of complexity and uncertainty, and so even technical management decisions may require some judgment.

DSS's are a class of information systems designed to help solve complex and poorly structured problems by augmenting human judgment. A

DSS will typically provide a set of tools that will support the process of problem structuring, understanding the problem, producing alternative solutions, and evaluating them (Guariso and Werthner 1989). To serve a broad range of users, DSS's must facilitate understanding of the analysis and the understanding and interpretation of its results (Langendorf 1985). DSS's have also been developed to facilitate group processes in decision-making (Bishop 1993). The advancement of DSS's in natural resource management is a necessary complement to traditional emphases on quantitative computing.

Within these general functional definitions, such systems can be diverse in specification, integrating hardware and software from various types of systems. Components of a DSS in environmental management can include: hypermedia databases, geographic information systems (GIS's), image processing, systems models, expert systems, intelligent and graphical user interfaces, and document handling. A hypermedia database combines information in multiple media (numbers, text, images, and sound) in an associative framework that links related information, facilitating knowledge building. Expert systems provide the foundation of decision-support by applying formalized expert knowledge to assist users in problem analysis and solution. Intelligence is also being built into the interfaces of systems to provide on-line assistance in the use of the system. Graphical user interfaces have become standard for displaying information in easily read displays of maps, graphs, diagrams, and images. Document handling allows system products to be disseminated beyond direct interaction with the system. The GIS, for mapping and analyzing spatial data, has become standard in environmental management, as most natural resources have a spatial dimension, and are a component of most environmental DSS's. Image processing is used both for the interpretation of satellite imagery and for the editing of viewshed images to simulate visual changes. Systems models are mathematical models of natural processes used to describe and predict resource dynamics and impacts.

Systems falling into this category are an area of rapid development in environmental management. Two systems under development for multiple-use lands are the TEAMS system (Covington et al. 1988) and the IRMA system (Loh et al. 1992). These integrate resource output models with spatial data, use expert assistance in the interface to guide the user, and provide graphical displays to allow visual inspection of data and model outputs. Examples of integrated systems for protected areas are systems for the Channel Islands National Park (Reynales 1990) and Redwood National Park (Rogers 1990). These systems integrate database management with GIS capabilities and record expert resource knowledge to support the protection of natural and cultural resources for those sites. Broad utilization of GIS has been limited by the expertise required to operate the systems; intelligence in GIS systems can be used to aid users with unfamiliar phenomena, models, and systems (Coulson et al. 1991). Similarly, expert systems are being developed to assist non-specialist managers with visual resource assessments (Buhyoff et al. 1994). Graphical user interfaces have been applied in developing a user-friendly information system to transfer research findings to managers (Reyes et. al. 1993). Hypermedia systems have been proposed as a format to integrate, store, and make accessible large bodies of knowledge, such as that relating to global climate change (Rauscher et al. 1993). Most of these systems apply visualization in various forms—maps, images, diagrams, and graphs—to more effectively communicate environmental information and enhance understanding. System developers generally proclaim, and take for granted, the power of visualization. The next section describes the capabilities of visualization and why it is particularly suited for environmental information.

Environmental Visualization

We define visualization generally as the use of visual representations to aid visual cognition and visual communication. Visual cognition is regarded as one of the more powerful capacities of the mind, and visual representations have the ability to represent large amounts of information. Visualization has a long history of use in the arts (Arnheim 1964), design (McKim 1972), geography (MacEachren et al. 1992), and science (Ferguson 1977). Advances in graphical computing have stimulated current development in scientific visualization (McCormick et al. 1987) and environmental visualization (Orland 1992). Information technology has greatly increased our ability to capture and create images, thus increasing support for visual thinking and communication.

Visual Cognition and Cognitive Landscapes

Visual cognition can be defined to include the perception, processing, and storage of visual information. Visual cognition is characterized as being direct, holistic, and memorable (Haber and Wilkinson 1982). Visual information is encoded directly, without translation into other mental representations (like words or numbers), allowing quick processing. Visual patterns are perceived holistically; all elements and their visible relationships are recognized simultaneously, and even subtle or complex patterns are discernible. Retention of visual information is higher than for words or numbers, with the long-term memory of visual information apparently unlimited. An irony of visual cognition is that it is so pervasive and facile that it is not apparent to us how much we employ it (Kaplan and Kaplan 1982). The power of visual cognition suggests that it has inherent capabilities to deal with the quantity and complexity of ecosystem information.

Visual cognition, beyond having the power to handle the complexity of ecosystem information, may be particularly structured for understanding ecosystems. Evolutionary theory would suggest that natural selection favors those humans better adapted to understanding their environment. Environmental psychologists think that humans construct a mental model of the landscape (ecosystem) through their interaction with the environment (Kaplan 1973). Visual perception is the primary source of information for this mental landscape model (Kaplan and Kaplan 1982). The majority of research on these models has focused on how they function as *cognitive maps*, representing space, location, direction, and scale in the environment (e.g., Downs and Stea 1977). But, in addition to spatial structure, it is apparent that the mental model must also represent the function of the system; the model is used to explain and predict how the environment works (Kaplan 1973). Moreover, the mental model includes subjective evaluations that humans associate with environmental features. Landscapes can have utilitarian resource values, experiential aesthetic values, and symbolic social values. In light of the multi-dimensional nature of the mental model, which is reflective of the system that it attempts to represent, it may be more appropriate to refer to the mental model as a *cognitive landscape*. The cognitive landscape is the source of understanding and the basis of acting in the environment, making it the foundation for environmental decision-making (Kaplan and Kaplan 1982). The cognitive landscape is largely constructed through visual perception of the landscape, and it can be visually imagined. It follows that visual representations of the landscape can facilitate clear communication and be readily assimilated into the mental model.

Visual Representations

Visual representations, or *visualizations*, are artifacts made to facilitate visual thinking and visual communication (after McKim 1977; MacEachren et al. 1992). Common examples in environmental management are the use of maps to show the spatial distribution of resources, and the use of graphs to show quantities of resources and their attributes. Visualizations act as external representations of mental imagery and function to extend the working memory of the brain, allowing us to think about larger and more complex problems than we can unaided (Norman 1993).

Visualizations may range from realistic, as in the case of video movies, to abstract, as in the case of data graphs. *Realism* tends toward representing the complete set of attributes of the real object, and the representation tends to have the same form as the real object (that is, tends to be isomorphic). *Abstraction* tends toward representing a reduced set of attributes of the real object, and the representation's form may have no similarity to that of the object. Realistic representations have the quality of *concreteness*; being perceived as closer to the actual direct experience of a real object, versus being abstract and indirect. As abstractness increases, the viewer must rely increasingly on prior knowledge to recognize the representation. As realism increases, the representation comes closer to being an experiential analogue. The concreteness of visualizations can promote clarity in understanding and communication over the use of language, which can be ambiguous and prone to stereotyping (Kaplan and Kaplan 1982). Abstraction does have the function of focusing attention to specific attributes of a object, and is part of the process of analysis and building concepts about things (Muerchke 1981).

A fundamental distinction between visualizations is whether the representation is of things that can be seen—*perceptual*; or is a visual representation of invisible objects or abstractions and concepts about things —*conceptual* (McKechnie 1976). Visualizations are intrinsically useful for representing physical phenomena (such as landscapes) because they have a spatial form by which they are visibly perceived, and which can be represented similarly in depicted form. Invisible physical phenomena, such as nutrient cycling, can be visualized conceptually by representing its spatial form and movement visibly in a diagram. Ecologists use diagrams of food webs, nutrient cycles, and hydrology for communicating landscape processes. Even non-physical things, such as knowledge domains, can be represented visually, making them easier to conceptualize through spatial metaphor. Visible objects can also act as symbols of associated concepts, such as the use of landmarks and artifacts in historical interpretation to make history more concrete.

Utility of Visualization in Ecosystem Management

We suggest that visualization has a necessary role in decision-making for ecosystem management. Consider the following points that summarize and build on the preceding discussion. First, the concept of cognitive landscapes suggests that humans are innately predisposed to learning about landscapes, with visual cognition as the dominant mode. Second, the ability to recognize patterns in visual information suggests an increased capacity to perceive complex phenomena, if represented visually. Third, visualizations allow humans to analyze and transform more complex objects than they can without external representations. Fourth, the strong memory for visual information can aid retention of learning (Rieber 1994). Fifth, the concrete, object-oriented quality of visualizations should bolster communication across language differences and across different areas of experience and specialization (Kaplan and Kaplan 1982). Sixth, evidence suggests that visualization should enhance the ability to generate innovations; visual thinking is known to be linked to creative thinking in the brain (Sperry

1973), and has been demonstrated to improve creative problem-solving (Antonietti 1991). Here are some examples of types of visualizations and how they have been applied in environmental management.

Visual simulations. Visual simulations are perceptual visualizations, primarily used by landscape architects, for realistically modeling visible changes in built and landscape features (Sheppard 1989). Visual simulation has been used to model encroachment on viewsheds of historic sites, such as Manassas National Battlefield, and to depict the character of development schemes in Yosemite National Park (Adams 1990). These models provide objective representations of visual change that permit each individual to personally evaluate change in visual quality and facilitate collaboration in planning and design.

Data graphics. Data graphics are conceptual visualizations, primarily used to aid statistical exploration and analysis (Tukey 1977). The basic example of this type is the two-variable graph, such as the runoff hydrograph that shows stream flow over time. *Scientific visualizations* are primarily of this type. Animated graphical displays of multivariate and dynamic systems allow scientists to see patterns in data that they could not before (see Earnshaw and Wiseman 1992). Such visualizations can also be useful in the communication of scientific knowledge to managers and users. Graphs and charts have been used in forest management software to facilitate comparison of resource outputs under varying management alternatives (Covington et al. 1988). Thematic maps, such as produced by GIS, can be data visualizations.

Multimedia maps. Maps vary from realistic, as in aerial photographs, to abstract, as in thematic maps, and though typically 2-dimensional plan views, they can also be cross-sections or other representations of earth systems (Muehrcke 1980). The use of GIS technology allows the digital representation of maps, and multimedia technology allows the integration of images, sounds, and text with the digital map. Hamilton and Flaxman (1992) are developing a spatialized multimedia database on the biological diversity of a natural area in the Sierra Nevada of California.

Graphical User Interfaces. Information systems are increasingly using graphical displays to represent the system to the user. These displays provide access to the functions of the system and enhance communication of information output by the system. In large databases, visual maps of the information are important to comprehension and navigation of the database. Icons are often used in place of words to represent programs and commands compactly and legibly. The interface may even be represented as a visual-spatial environment, as in the desktop metaphor of the Apple computer's operating system.

Place images. Place images are perceptual visualizations of real sites that show the pattern of major elements in one view. These models are typically aerial oblique perspectives and may be combined with reference maps and ground-level perspectives. Such models facilitate the conceptualization of the overall structure of a landscape. This model has been used in urban and landscape planning for communicating alternative development scenarios. A recent notable example is its extensive use in the landscape planning manual, *Dealing with Change in the Connecticut River Valley: A Design Manual for Conservation and Development* (Yaro et. al. 1989). From these representations people can also interpret various qualities, such as settlement density, habitat patterns, visual character, and social interaction.

Explained Images. Words can added to an image to explain its object: language adds conceptual content to a visualization. The simplest form of such a representation is a captioned picture. More powerful computerized examples include hypermedia databases that embed information links within pictures, or expert systems that interact with a user to analyze images. An example of such an expert system developed for visual resource management is the Explanation of Visual Assessments (EVA) system developed by Buhyoff et al. (1994).

Impact matrices. Impact matrices are conceptual visualizations that show interactions of resources and management, and the resulting impacts on ecosystem structure and function. The formatting of the information in a matrix allows a holistic comparison of impacts across the components of a system. This type of visualization is commonly used in environmental impact assessment.

Semi-formal models. Semi-formal models combine perceptual and conceptual visualizations to represent both the structural and functional dimensions of human ecosystems for planning and design (Lyle 1991). They are particularly useful for aiding conceptual comprehension, communication, participation, and alternative generation. A typical model of this type is a diagrammatic three-dimensional graphic of a landscape and its significant processes. A relevant example is a water budget model for a lake for dry and wet seasons of a year. The approximate volume of water flows is represented in the size of flow arrows and storage blocks, facilitating the comparison of water volumes from the various inputs (Lyle 1991). Such a model provides at once both the conceptual model for shared understanding and an artifact on which to base communications about the system.

A Decision-Support System for NRGNR

We now return to the case of the NRGNR and its need to promote collaborative management. The following proposal is a concept for an information system that would support a broad range of research, management, and recreational users in the NRGNR. These ideas arise from our shared experience in planning for the

New River Parkway (Williams and Skabelund 1995) and in developing environmental information systems, including the development of an expert system for visual resource management (Buhyoff et al. 1994), the development of a multimedia database and tutorial for barrier-free recreational design (Bork et al., in press), and the design of a hypermedia database for a natural area (O'Brien 1995). This proposal is voluntary on our part and in no way the responsibility of the National Park Service.

A fully developed DSS would, ultimately, include a hypermedia database, a GIS, image processing, systems modeling, expert systems, an intelligent graphical interface, and document handling as described earlier. But developing such a system would require a substantial funding commitment, a team of specialized personnel, and extensive data sources. This is a worthy long-term goal, but in the short term there is an initial intermediate approach that could still produce a broadly useful, yet economical, system. The first step would be to begin construction of the hypermedia database with stand-alone GIS and image processing systems. The database would be simply a descriptive compilation of the available information on the landscape, its management, and its stake-holders. This compilation would provide the foundation for the later construction of a more sophisticated formal DSS. The GIS and image-processing systems would provide the necessary spatial data-handling and visualization capabilities. These systems would not require as much expertise for information input as would more sophisticated and complex systems, and the use of existing stand-alone software would minimize investment in software development. Most of the NRGNR's learning and communication needs could be supported through this combination of systems. Basic functions of the system would be to provide a research compilation, a management record, a resource inventory, and a source of media and content for interpretive programming and public communication. Expert systems, systems models, integrated shells, and other sophisticated expansions could be developed later as needed and funded.

Visualization for the Land Management System

An important application of this system would be to provide visualization services as a technical outreach to aid local governments plan compatible developments in the gateway communities of the National River. The Land Management System proposed for the New River Parkway currently under study (USDOT and WVDOH 1994) is a fitting example. The Land Management System is a set of land-use regulations and design guidelines intended to protect water, vegetative, and visual resources in the corridor of the New River Parkway (Williams and Skabelund 1995). Local governments would be responsible for administering the system on private lands in the corridor, under the review and advisement of the New River Parkway Authority, on which the USNPS has a non-voting member.

There is little tradition of land-use regulation in the region, and public appreciation and support for it must be developed. To aid implementation of the Land Management System, some basic learning needs must be addressed. First, land development is an interaction of processes occurring incrementally over an extended period of time, and people typically do not anticipate the results of cumulative change. Second, the alternative development patterns implied in the Land Management System guidelines are novel to most of the decision-makers, so they will have difficulty understanding and evaluating them. Visualization provides the best medium for representing concretely these interacting dynamics and novelty, to support understanding of environmental change, and engage collaboration in guiding change.

Visualizations have been specified in the preliminary concepts of the Land Management System. Maps would be prepared of the *Scenic Corridor Site Plan* that identify management zones, and graphic examples of the design guidelines and performance standards would be used in the *Planning and Design Handbook.* Additional visualizations that would also be applicable are place images, visual simulations, and semi-formal models. Place images would provide an overview of the density and character of alternative development scenarios for the corridor. Visual simulations would provide realistic representations of landscape changes that allow anticipation of its future character. Semi-formal models could be used to develop a conceptual understanding of hydrology and water quality issues related to the development impacts of storm water run-off and septic systems.

Planning and implementation based on concrete visual models of the proposed development scenarios would facilitate people's understanding of possible environmental changes and the relative costs and benefits of the various management responses. Used in a participatory social process, these visualizations may help to overcome stereotypical negative responses to regulation and the consequent lack of adoption, compliance, and enforcement. With a holistic representation of the possible landscape and its qualities, people might see that they prefer the environment achieved through collaboration. Without the aid of visualizations, agreement on what the problems are and what the preferred alternative is would be more difficult and may not be achieved at all, leaving current land-development trends unchanged. Similarly, if the consequences of greater environmental changes, such as climate change and extinction, are not made concrete and meaningful to peoples' experienced quality of life, it does not seem likely that alternatives will be considered.

Conclusions

Collaboration is required for achieving sustainable management of protected areas and other ecosystems, and collaboration is necessarily founded on shared understanding and clear communications. The continued development of DSS's can improve human judgment to guide the complex and contentious issues of ecosystem management. Human capabilities for visual cognition need to be utilized in the functions of an environmental DSS. Visualization will enhance understanding and communication across the range of stakeholders and should be a significant capability of the DSS.

The potential implementation of this proposal is not limited by technology, but by funding. Budgets for basic USNPS functions, not to mention developing information systems, have been inadequate. Increased funding for research has been advocated by scientific institutions (NRC 1992) and conservation organizations (NPCA 1989). The importance of protected areas to understanding and resolving larger environmental problems, like land degradation, climate change, and species extinction, reinforce the need for such an investment. However, current political trends offer little prospect for immediate funding. It is beyond the scope of this discussion to offer political strategies to resolve this problem. However, we have suggested that the communication functions of such a system could be applied to building public understanding and support for protected areas. This sets up the dilemma of which comes first—the support to develop the communications, or the communications to build the support. A near-term strategy of developing partnerships and combining resources with other institutions, such as regional colleges and universities, is one way for the NRGNR to begin constructing the type of information system proposed here.

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The Visitor Experience and Resource Protection (VERP) Process:

The Application of Carrying Capacity to Arches National Park

Introduction

As the name suggests, national parks are resources of national and, increasingly, international significance. The United States national park system, for example, contains natural, historical, and cultural resources of great importance to the nation and, in many cases, the international community. Given the significance of this resource base, public demand to see and experience these areas should not be surprising.

Data on national park visitation in the U.S. dramatically support this premise. Annual visitation to the national parks is now counted in the hundreds of millions. In the decade of the 1970s, visitation increased by 30 percent. In the 1980s, visitation rose another 35 percent. If this trend continues, the national parks can expect to receive over 300 million visits by the year 2000.

The increasing popularity of the national parks presents both an opportunity and a challenge. The opportunity is to fulfill the mission of the national parks "to provide for the enjoyment of the people." The accompanying challenge, of course, is to conserve park resources for the enjoyment of future generations. This can prove difficult under conditions of high visitation.

Implicit in this dual mission of national parks is the issue of the *quality of the visitor experience.* The quality of visitor experiences must be maintained at a high level for the national parks to contribute their full potential to the enjoyment of society. Moreover, high-quality visitor experiences are more likely to develop public appreciation of, and support for, conservation of national park resources.

It is ironic that one of the greatest threats to the quality of national park visits is commonly seen as their increasing popularity. To many observers, the national parks, at least in some places and at some times, are crowded, and this detracts from the quality of the visitor experience. Moreover, natural and cultural resources can be degraded by excessive visitor use. In more formal terms, the use of some national parks, or portions thereof, have exceeded their *carrying capacity* (Mitchell 1994; Wilkinson 1995).

This paper explores the theory and application of carrying capacity to the national parks. Primary emphasis is placed on *social* carrying capacity. The first section briefly traces the theoretical development of the carrying capacity concept. The second section describes a process now being developed within the U.S. National Park Service to help determine and manage carrying capacity in the national park system. The final section outlines the application of this carrying capacity process to Arches National Park as a model for the national park system.

The Concept of Carrying Capacity

The question of how much public use is appropriate in a national park is often framed in terms of carrying capacity. Indeed, much has been written about the carrying capacity of the national parks and related areas. The underlying concept of carrying capacity has a rich history in the natural resource professions. In particular, it has proven a useful concept in wildlife and range management where it refers to the number of animals of any one species that can be maintained in a given habitat (Dasmann 1964). Carrying capacity has obvious parallels and intuitive appeal in the field of park management. In fact, it was first suggested in the mid-1930s as a park management concept in the context of the national parks (Sumner 1936). However, the first rigorous applications of carrying capacity to park management did not occur until the 1960s.

These initial scientific applications suggested that the concept was more complex in this new management context. At first, as might be expected, the focus was placed on the relationship between visitor use and environmental conditions. The working hypothesis was that increasing numbers of visitors causes greater environmental impact as measured by soil compaction, destruction of vegetation, and related variables. It soon became apparent, however, that there was another critical dimension of carrying capacity dealing with social aspects of the visitor experience. Wagar (1964), for example, in his early and important monograph on the application of carrying capacity to recreation, reported that his study "was initiated with the view that carrying capacity of recreation lands could be determined primarily in terms of ecology and the deterioration of areas. However, it soon became obvious that the resource-oriented point of view must be augmented by consideration of human values."

Wagar's point was that as more people visit a park, not only can the environmental resources of the area be affected, but the quality of the visitor experience as well. Again, the working hypothesis was that increasing numbers of visitors cause greater social impacts as measured by crowding and related variables.

Thus, as applied to national parks, carrying capacity has two components: environmental *and* social.

The early work on social carrying capacity has since blossomed into an extended literature on social aspects of outdoor recreation and their application to carrying capacity (Stankey and Lime 1973; Manning 1985; Kuss et al. 1990; Shelby and Heberlein 1986; Lime and Stankey 1971; Manning 1986; Graefe et al. 1984). But despite this impressive literature base, efforts to determine and apply social carrying capacity to areas such as the national parks have often failed. The principle difficulty lay in determining how much impact, such as crowding, was too much. Theoretical development, backed up by empirical research, generally confirms that increasing contacts or encounters between visitors leads to increased perceptions of crowding. But how much crowding should be allowed in a national park? This basic question is often referred to as the "limits of acceptable change" (Lime 1970; Frissell and Stankey 1972). Given substantial demand for public use of a national park, some decline or change in the quality of the visitor experience (e.g., some crowding) appears inevitable. But how much decline or change is acceptable or appropriate before management intervention is needed?

This issue is illustrated graphically in Figure 1. In this figure, two hypothetical relationships between visitor use and crowding are shown. It is clear from both that visitor use and crowding are related: increasing numbers of visits cause increasing percentages of visitors to report feeling crowded. However, it is not clear at what point carrying capacity has been reached. The relationships in Figure 1 illustrate that some crowding is inevitable, given even relatively low levels of visitor use. Thus, some level of crowding must be tolerated if national parks are to remain open for public use. For the relationship defined by line A, X_1 and X_2 represent levels of visitor use that result in differing levels of crowding as defined by points Y_1 and Y_2, respectively. But which of these points—Y_1 or Y_2, or some other point along this axis—represents the maximum amount of crowding that is acceptable? Ultimately, this is a value judgement. Again, the principal difficulty in carrying capacity determination lies in deciding how much crowding (or of some other impact) is acceptable. Empirical relationships such as those in Figure 1 can be helpful in making informed decisions about carrying capacity, but they must be supplemented with management judgments.

To emphasize and further clarify this issue, some writers have suggested distinguishing between descriptive and evaluative (or prescriptive) components of social carrying capacity determination (Shelby and Heberlein 1986). The descriptive component of social carrying capacity focuses on factual, objective data such as the types of relationships in Figure 1. For example, what is the relationship between the number of visitors entering an area and the number of encounters that occur between groups of visitors? Or what is the relationship between the intensity of visitor use and visitor perceptions of crowding? The evaluative or prescriptive component of social carrying capacity determination concerns the seemingly more subjective issue of how much impact or change in the visitor experience is acceptable. For example, how many contacts between visitor groups are appropriate? What level of perceived crowding should be allowed before management intervention is needed?

Recent experience with carrying capacity suggests that answers to the above questions can be found through formulation of management objectives and development of indicators and standards of quality (National Park Service 1992; Shelby et al. 1992; Stankey et al. 1985; Graefe et al. 1990; Stankey and Manning 1986). This approach to carrying capacity focuses principal emphasis on defining the type of visitor experience to be provided and maintained, and then monitoring conditions over time to assess whether or not acceptable conditions have been exceeded.

Management objectives are broad, narrative statements which define the type of visitor experience to be provided. They are based on review of the purpose and significance of the area under consideration. Formulation of management objectives may involve review of legal, policy

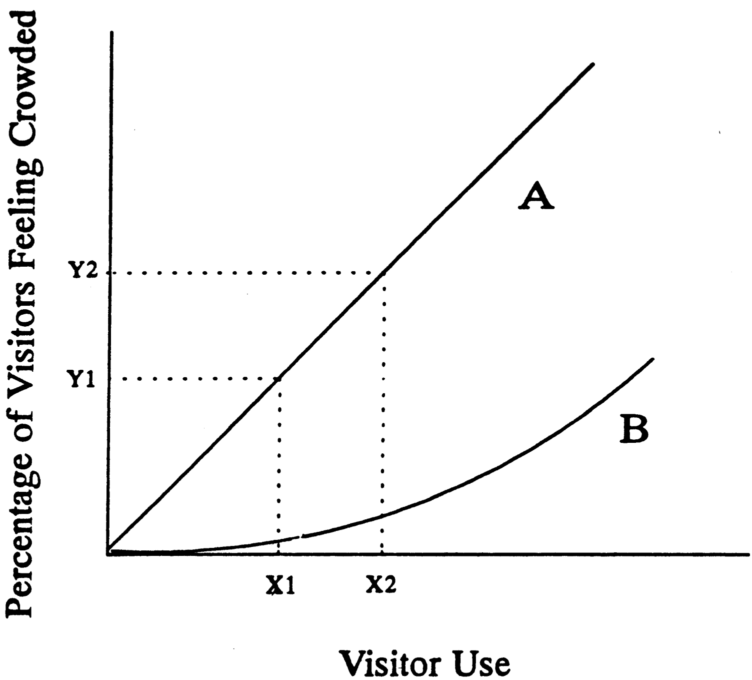

Figure 1. Hypothetical relationships between visitor use and crowding

and planning documents, consideration by an interdisciplinary planning and management team, and public involvement.

Indicators of quality are more specific measurable variables which reflect the essence or meaning of management objects; they are quantifiable proxies or measures of management objectives. Indicators of quality may include elements of both the physical and social environment that are important in determining the quality of the visitor experience. *Standards of quality* define the quantitative and measurable condition of each indicator variable.

An example of management objectives, indicators, and standards may be helpful. Review of the U.S. Wilderness Act of 1964 suggests that areas contained in the National Wilderness Preservation System are to be managed to provide opportunities for visitor solitude. Thus, providing opportunities for solitude is an appropriate management objective for most wilderness areas. Moreover, research on wilderness use suggests that the number of visitors encountered along trails and at campsites is important to wilderness visitors in defining solitude. Thus, trail and camp encounters become key indicators of quality and help to make the general management objective of solitude more operational. Further research suggests that wilderness visitors often have normative standards about how many trail and camp encounters can be tolerated before the quality of the visitor experience declines to an unacceptable degree (Vaske et al. 1986; Whittaker and Shelby 1988; Heberlein et al. 1986; Roggenbuck et al. 1991; Shelby and Vaske 1991). This consensus (sometimes called "social norms") among visitors helps to define a standard of quality.

By defining indicators and standards of quality, carrying capacity can be determined and managed through a monitoring program. Indicator variables can be monitored over time; once standards have been reached, carrying capacity has been reached as well. This approach to carrying capacity is central to contemporary park planning frameworks, including Limits of Acceptable Change (LAC) (Stankey et al. 1985), Visitor Impact Management (VIM) (Graefe et al. 1990), Carrying Capacity Assessment Process (C-CAP) (Shelby and Heberlein 1986), Quality Upgrading and Learning (QUAL) (Chilman et al. 1990), Recreation Management Planning Process (Manning 1986), and the Visitor Experience and Resource Protection (VERP) process currently under development by the National Park Service (National Park Service 1993; Hof et al. 1994).

Carrying Capacity in U.S. National Parks: The VERP Process

The U.S. National Park Service has long recognized the need to apply the concept of carrying capacity to parks that have been experiencing problems from increasing public use. In fact, the 1978 U.S. General Authorities Act requires each park's general management plan to include "identification of and implementation commitments for carrying capacities for all areas of the unit" (U.S. Congress 1978). Although Park Service management policies and planning guidelines acknowledge this responsibility, there has been little direction or agreement on an approach or methodology for how to identify a park's carrying capacity. Park planners and managers have been reluctant to state that parks, or areas within parks, are receiving inappropriate or excessive use because they have lacked the rationale and empirical data to make such determinations.

For the past three years, an interdisciplinary team of Park Service planners, managers, and researchers has been developing a framework to identify and manage carrying capacity in the national park system. As described in the previous section, this framework is based on identification of appropriate resource and social conditions—indicators and standards of quality—to be achieved and maintained in the national parks. The process is called Visitor Experience and Resource Protection (VERP).

VERP consists of nine basic steps as shown in Figure 2. The first six steps are requirements of general park planning and ideally should be a part of each park's general management plan (GMP). The final three steps require periodic review and adjustment and are most appropriately handled through park operation and management activities. Briefly, the steps are as follows:

- In Step 1 a project team is assembled. This should be an interdisciplinary team comprising park planners, managers, and researchers.
- Step 2 consists of developing clear statements of park purposes, significance, and primary interpretive themes. This step clarifies the most basic assumptions about the park's use and management, and sets the foundation for the rest of the process.
- In Step 3 the park's important resources and potential visitor experiences are mapped and analyzed. The product of this step is a set of overlay maps showing the spatial distributions of important resources, landscape units, and the range of visitor experience opportunities.
- In Step 4 the team identifies potential management zones that cover the range of desired resource and social conditions consistent with the park's purpose. This is where the process begins to be prescriptive. Different actions will be taken by the Park Service in different zones with regard to the types and levels of uses and facilities. The zones are defined by carefully analyzing resource constraints and sensitivities, resource attributes for visitor use, and management goals for the park. The existing park infrastructure (roads, parking lots, etc.) is not a deciding factor in determining the zones.

- In Step 5 the team applies the potential management zones on the ground to identify a proposed plan and alternatives. A zoning scheme is identified by overlaying the potential management zones on the areas where the team believes that different visitor experiences should occur in the park. The park's purpose, significant resources, and existing infrastructure are also factored into this analysis. Different configurations of the potential management zones can lead to different alternatives.
- Step 6 involves selecting indicators of quality and specifying associated standards for each zone. The purpose of this step is to identify measurable physical, social, or ecological variables that will indicate whether or not a desired resource or social condition is being met. This is a pivotal step that defines the zones, transforming subjective descriptions into objective measurements of conditions in those zones.
- In Step 7 the park staff compares desired conditions with existing conditions. Each zone needs to be monitored to determine if there are discrepancies with the desired resource and social conditions.
- Step 8 consists of identifying probable causes of discrepancies in each zone. It is important in this step to accurately identify the root causes of the discrepancies.
- In Step 9 the park staff identifies management strategies to address discrepancies. Visitor use management prescriptions should start with the least restrictive measures that will accomplish the objective and move toward more restrictive measures if needed.

Although Step 9 is the final formal step shown in Figure 2, the process does not end there. Long-term monitoring is an essential element of the VERP process. Monitoring provides continual, systematic feedback to park managers to ensure that desired resource and visitor experience conditions continue to be achieved over the long term. In this way, carrying capacity has been identified and managed.

Carrying Capacity of Arches National Park

The VERP process described above is currently being applied at Arches National Park, Utah. The purpose of the test is to refine the VERP process and provide a model for the rest of the national park system. Research aimed at defining indicators and standards of quality for the visitor experience is described in this section. As noted earlier, indicators and standards of quality are pivotal points of carrying capacity determination. Complimentary research has addressed indicators and standards for natural resource conditions such as soil disturbance and compaction and destruction of vegetation.

Arches National Park is covers 73,000 acres of high-elevation desert with outstanding slick rock forma-

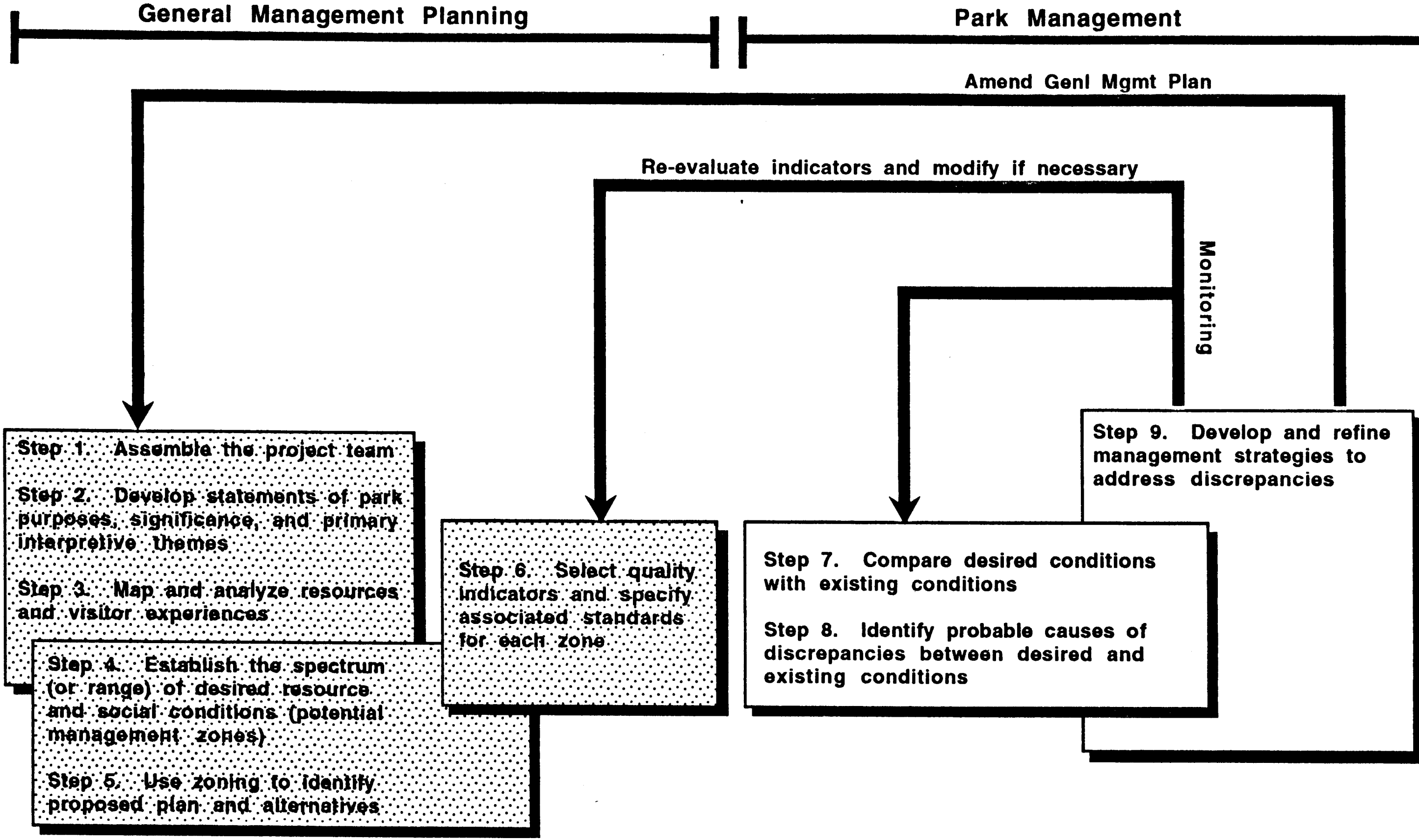

Figure 2. Visitor Experience and Resource Protection (VERP) process.

tions, including nearly 2,000 stone arches. Most of the park's scenic attractions are readily accessible through a well-developed road and trail system. Visitation to Arches has been increasing rapidly. The number of visits increased 91 percent in the decade of the 1980s, and the park now receives over three quarters of a million visits annually with use continuing to increase at a substantial rate.

Following the VERP model, an interdisciplinary project team was created, composed of planners from the Park Service's Denver Service Center, Arches National Park staff, and USNPS scientists (Step 1). Workshops were conducted to develop statements of park purposes, significance, and primary interpretive themes (Step 2). Authorizing legislation and the current General Management Plan provided important reference sources. Park resources and existing visitor experiences were then mapped (Step 3) and a spectrum of desired resource and social conditions was constructed using a simple matrix format (Step 4). Based on this analysis, a system of nine zones ranging from developed to primitive was created and overlaid on the park (Step 5).

Step 6 requires selecting indicators of quality and specifying associated standards for each zone. This required a social science research program that was conducted in two phases. Phase I was aimed at identifying potential indicators of quality (Manning et al. 1993). Personal interviews were conducted with 112 visitors throughout the park. In addition, ten focus group sessions were held with park visitors, park staff, and local community residents. Respondents and participants were selected through a purposive rather than random sampling procedure. Thus, data are primarily qualitative in nature. This exploratory effort was conducted to develop insights into potential indicators of the quality of the visitor experience. Interviews and focus group sessions were guided by a standardized questionnaire.

The questionnaire contained two major sections that focused on identifying potential indicators of the quality of the visitor experience. The first section contained a battery of open-ended questions which probed for park conditions and issues which visitors and others considered important to determining the quality of the park experience. The second section contained a battery of close-ended questions which also probed for indicators of quality. Fifty-three wide-ranging park conditions or issues were presented to respondents who were asked to indicate the extent to which each item was considered to be a problem in the park. The items presented were developed on the basis of literature review, discussion with park planners and staff, and personal observations in the park.

Findings from the Phase I research suggested several indicators of quality for the park, including the number of people at frontcountry attraction sites and along trails, the number of parties encountered along backcountry trails and at campsites, the number of vehicles encountered along roads, the number of social trails and associated soil and vegetation impacts, the level of trail development, and visitor knowledge of regulations regarding off-trail hiking.

Phase II of the research program was designed to identify specific indicators of quality and set associated standards (Lime et al. 1994). The primary objectives of this phase of research were to determine the relative importance of indicator variables across the nine park zones and to set standards for the most important indicator variables. A survey of park visitors was conducted, covering all nine park zones. The survey was administered to a representative sample of over 1,500 park visitors by means of both personal interviews and mail-back questionnaires.

The survey instruments contained two major sections related to carrying capacity and the VERP process. The first section focused on determining the relative importance of indicator variables identified in Phase I research. Fourteen indicator variables were distilled from the previous phase of research, and respondents were asked to rate the importance of each variable in determining the quality of their experience at the park zone in which they were interviewed. This section of the questionnaire was needed for two reasons. First, Phase I research was qualitative in nature; its purpose was simply to explore for potential indicators of quality. Phase II research was needed to become more quantitative by asking respondents to rate the relative importance of these potential indicators of quality. This required a larger and more representative sample. Second, it was hypothesized that indicator variables would vary by park zone. Sampling was conducted in all nine park zones, and questions were keyed directly to those specific areas. This zoning approach is appropriate to carrying capacity and the VERP process as relatively large areas such as national parks can and probably should provide a variety of visitor experiences.

The second major section of the survey questionnaires was directed at determining standards of quality for selected indicator variables. Five indicator variables received special attention: 1) the number of people at one time at major frontcountry attraction sites, 2) the number of people at one time along frontcountry trails, 3) the amount of environmental impact caused to soil and vegetation by off-trail hiking, 4) the number of parties encountered along backcountry trails and at campsites, and 5) the number of vehicles encountered along unpaved roads. The first three of these variables were addressed by a series of photographs which illustrated a range of impact conditions. Photographs were developed using a computer-based image capture technology (Pitt 1990; Lime 1990; Nassauer 1990; Chenoweth 1990). Base photographs of park sites were taken, and these images were then modified to present a range of impact conditions (e.g., number of visitors present, amount of environmental impact). A set of sixteen photographs was developed for each major attraction site and trail, presenting a wide-ranging number of visitors present. An analogous set of photographs was developed for a range of environmental impacts caused by off-trail hiking. Respondents rated the acceptability of each photograph on a scale of -4 (very unacceptable) to +4 (very acceptable). Representative photographs for the number of visitors at Delicate Arch and environmental impact along the trail to Delicate Arch are shown on the Cover and in Figure 3, respectively. Questions regarding encounters in the backcountry and along unpaved roads were asked in a more conventional narrative format.

Earlier in this paper, it was noted that social norms often exist concerning important elements of the visitor experience. That is, there is often some consensus among visitors about how much impact can be tolerated before the quality of the experience declines to an unacceptable degree. Methodological techniques have been developed and refined to measure such social norms of park visitors (Heberlein et al. 1986; Manning 1985; Shelby et al. 1992; Shelby and Heberlein 1986; Vaske et al. 1986; Whittaker and Shelby 1988). The research program at Arches National Park was built on these techniques.

Findings from Phase II research provided the basis for selection of indicators and standards of quality for each of the nine park zones. Where appropriate, at least one social indicator was chosen for each zone and standards were set for each indicator variable. For example, the "pedestrian" zone contains several of the most prominent attraction sites in the park, including Delicate Arch. Visitors reported that the number of people at such attraction sites at any one time was important in determining the quality of their experiences. Thus, the number of people at one time (PAOT) at Delicate Arch was selected as an indicator of quality for that zone. Moreover, findings from the series of 16 photographs of Delicate Arch (as shown in Figure 4) suggested that visitors generally find up to 30 PAOT to be acceptable. (It can be seen from the figure that the line tracing visitor evaluations of the sixteen photographs crosses from the acceptable range to the unacceptable range at 30 PAOT). Based on these findings, 30 PAOT was selected by the project team as the standard of quality. Indicators and standards of quality were set for all zones in this manner. A companion set of resource-based indicators and standards of quality was set based on a program of ecological research (National Park Service 1995).

A monitoring program focused on indicators of quality has been designed and is now being implemented in the park. This will allow park staff to address steps 7, 8, and 9 of the VERP process. This monitoring program will determine the extent to which standards of quality are

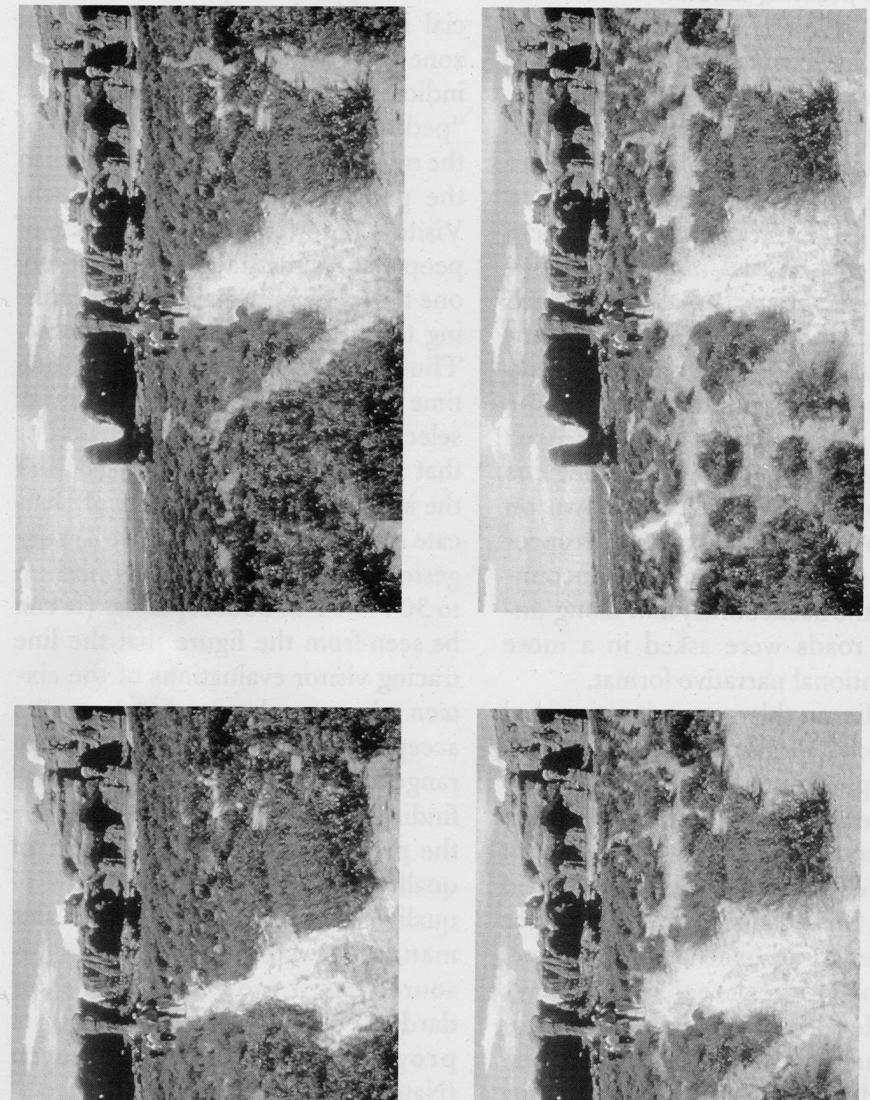

Figure 3. Representative photographs showing alternative levels of environmental impact on the trail to Delicate Arch.

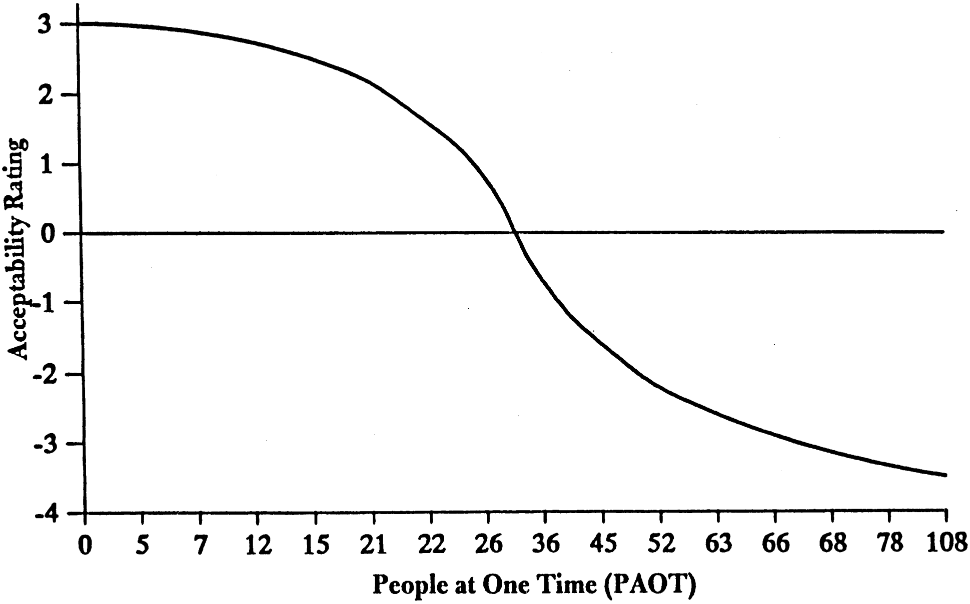

Figure 4. Visitor evaluation of 16 photographs of Delicate Arch showing alternative levels of visitor use.

30 PAOT at Delicate Arch) are not violated. Parking lot size can be adjusted up or down depending upon monitoring results. The VERP process requires management action whenever standards of quality have been violated. Park managers must be prepared and committed to initiating such management actions.

Conclusion

Nearly thirty years of research and development on the concept of carrying capacity has led to development of several planning and management frameworks. All of these carrying capacity frameworks rely on a similar series of steps. VERP is specifically designed to identify and manage carrying capacity in the national park system. Carrying capacity is determined by developing desired resource and social conditions through a series of indicators and standards of quality. Indicators are monitored over time, and when associated standards of quality have been reached, carrying capacity has been reached as well. If standards are violated, the VERP process requires that management action be taken.

VERP is now being applied at Arches National Park. The park has been divided into a series of zones, and, through a program of research, social and resource indicators andbeing met, and will help develop insights into the causes of any violations of standards. Park managers are planning to use parking lot size at attraction sites and trailheads as a primary management tool. The monitoring program will help determine the appropriate size of parking lots to ensure that standards of quality (e.g., standards of quality have been specified for each zone. A monitoring program is now being instituted in the park to insure that standards of quality are not violated and to determine when and where management action is needed to keep park use within carrying capacity. Additional applications of VERP are now being undertaken at several Park Service areas, including Acadia National Park, Glacier National Park, Mount Rainier National Park, and Saint Croix National Scenic Riverway.

VERP provides a theoretically sound and rational process for determining and managing carrying capacity in the national park system. An associated research program can provide a strong empirical basis for applying the VERP process. Arches National Park provides a model for applying the VERP process throughout the national park system.

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Finance
is the art of passing currency
from hand to hand
until it finally
disappears

Robert W. Sarnoff

Jeffrey A. McNeely

Coping with Change

People, Forests and Biodiversity

Throughout history, forests have been a basic support system for society, providing goods such as timber, game meat, fodder, and medicinal plants, and services such as soil formation, watershed protection, and climatic improvement. People have often sought to enhance a certain attribute of forests at the expense of others, thereby providing—in the judgement of those making the decisions—the best mix of forest benefits to society. However, these judgements have not always led to sustainable use of forest products. The choices about the use of forest resources have nevertheless had a great influence on the structure and composition of the forest system.

What can historical experience tell us about the way forests are being used today? How can a historical perspective help us use forests better in the future? Answering these questions requires an objective consideration of the influences people have had on forests throughout history.

In western culture, "nature" is often considered to be that which operates independently of people (Hoerr, 1993), and a major focus of development has been to bring nature under greater human control. In fact, "progress" is often measured by technological innovations which have enabled humans to gain a greater share of the planet's productivity. Conservation, on the other hand, has been based on the idea of setting aside large tracts of nature that are in a state of imagined innocence and converting them into national parks and other kinds of protected areas. Forests which are "pristine" or "virgin" or "primary" are thus given particularly high value for conservation and considered likely to have particularly high biological diversity.

Despite the dominance of this view of nature, studies in such areas like archaeology, history and forestry call into question the separation of people from nature, supporting instead the age-old view that people are *part* of nature and that biodiversity—that is, the variety of genes, species, and ecosystems—found in today's forests results from a combination of cyclical, ecological and climatic processes and past human action. Evidence is building to support the view that very few of today's forests anywhere in the world can be considered "pristine," "virgin," or even "primary," and that conserving biological diversity requires a far more subtle appreciation of both human and natural influences.

Delving into the history of forests and biodiversity leads us to the following four conclusions:

1) humans have been a dominant force in the evolution of today's forests;
2) as humans have developed more sophisticated technology throughout history, the impact thay have had on forests has tended to increase to the level where forests are degraded to the long-term detriment of the over-exploiting sociey;
3) over-exploitation is usually followed by a culture change which may reduce human pressure, after which some forests may return to a highly productive and diverse, albeit altered, condition and others may be permanently altered to much less productive and diverse conditions; and
4) the best approach to conserving forests and their biodiversity is through a variety of forms of management ranging from strict protection through intensive use, with a careful consideration of the distribution of costs and benefits of each management approach.

These conclusions can be drawn from the following review of the changes in forest use throughout human history.

Cycles, Forests, and Biodiversity

Natural cycles provide an essential framework for understanding the history of forest habitats. The daily passage of the sun and moon, and the longer cycles of the lunar months and solar years, are related to the shedding of leaves from trees in deciduous forests, population cycles of insects which affect forests, and movements of migratory species. The distribution and numbers of species are also affected by long climatic cycles which can bring periodic drought and fire to even ever-wet tropical forests. Different cycles affect biodiversity at different levels and at different speeds (from hours for some insects, to months for leaves and to millennia for continental landscapes). The critical processes at each of the levels can be seen as a cycle of birth, growth, death and renewal (Holling, 1986).

Foresters have often been inclined to give the most attention to the processes of birth and growth, trying to enhance productivity, in order to harvest the products. But the processes of death and renewal may be even more important, because these affect the capacity of the forest ecosystem to renew itself after disturbance and enable the cycle to continue. Renewal of a forest ecosystem following harvesting, fire or other form of disturbance, depends on the extent and nature of the disturbance and the diversity and mode of reproduction of species located in the forest (Maini, 1992). Disturbance is an important part of any forested ecosystem and helps set the timing of further cycles.

However, some disturbances can convert a diverse system into a much less diverse type of vegetation, through linkages with climate cycles, nutrient cycles, and hydrological cycles. Clark (1992), from a detailed study of "natural experiments," concluded, for example, that tropical deforestation could bring about essentially different ecosystems through its impact on local climate. If large areas of tropical forest are replaced by grassland, he found, annual moisture precipitation produced by vegetation (evapotranspir-ation) is likely to be reduced by about 300mm and rainfall by 650-800mm in these areas. Lower rates of evapotranspiration, he concluded, would lead to an increase in surface air temperatures of about 3°C, and reduced cloud cover would also lead to even higher temperatures, so the overall effect could be a rise in temperature of 4° to 5°C.

While these observations are controversial (Bruijnzeel, 1990; Bosch and Hewlett, 1982) and may apply only to the Amazon, it is apparent that in places where human influence has been intensive and long-standing and where soils are poor in nutrients, forests can be replaced by degraded savanna vegetation. In what is now Pakistan, the people of the Indus Valley in the fourth millennium BC destroyed the forested basis of their own livelihood. Similarly, what is now the Thar Desert in Rajastan and Punjab, India, was still tall forest 2,000 years ago, and the great stone faces which dot the grasslands of Easter Island bear silent witness to the forests that covered the remote island when humans first arrived some 1,500 years ago (Ponting, 1992). More recently, the forest in some parts of tropical Asia has been so disrupted that it now only consists of a combination of *Imperata* grasslands and bamboo which supports a very low biomass and diversity of vertebrates, and is very resistant to reforestation efforts (Sayer, McNeely, and Stuart, 1990).

The traditional ecological principle of a single steady state of vegetation is being replaced by the realization that the possibilities for community organization within any one landscape are effectively unlimited, especially in the tropics where species numbers are very high. The specific mix of species found at any site at any time is an accident of history, depending on what was there before, the way the habitat was disturbed, the order in which the various species arrived, and the influence of fires, diseases, humans, and so on during the process.

The vegetation of any area at a specific point in time has some special characteristics that make it different from other times in history. Because chance factors, human influence and small climatic variation can cause very substantial changes in vegetation, the biodiversity for any given landscape will vary substantially over any significant time period—and no one variant is necessarily more "natural" than the others (Sprugel, 1991). This implies that biodiversity conservation efforts may need to give greater attention to ecosystem **processes** than to ecosystem **products**.

But this perspective should not be carried too far. Not all possible assortments of vegetation are "natural"; a planted, fertilized, pesticide-saturated pasture dotted with cows, or a forest of genetically identical rubber trees planted in formations like a training regiment of army recruits is not a natural ecosystem by any reasonable definition. Further, it is clear that certain species of flora and fauna that may be of special concern to people are very susceptible to human activities and rapidly disappear from areas of heavy usage of forests. For example, large-bodied primates are easily hunted and decline rapidly in exploited habitats, so high densities of many of the large primates are now restricted to protected areas in many parts of the tropics (Bodmer and Ayres, 1991).

Different systems of forest management, and of the understanding of the forest dynamics on which they are based, may enhance or reduce their diversity. The most species-rich areas are likely to be found in high-rainfall areas covered by a wide range of different ecosystems, including secondary forest in various stages of recovery interspersed with patches of old-growth forest. Completely excluding human intervention may reduce both genetic and species diversity by changing the mix of successional stages, although in other circumstances strictly limiting human impact may be necessary for conserving certain species. The notion of "natural" vegetation or ecosystem processes is still useful as a goal for forest management, though it must be revised to recognize that a range of ecosystems can legitimately be considered "natural" (Sprugel, 1991), and almost all of them will have been significantly influenced by people. The crucial point is that governments and people must consider what kind of ecosystem they actually want. It is not enough simply to preserve the existing landscape, or seek to re-create one from the past. Ecosystems are dynamic. They must evolve. But what should any ecosystem be allowed, or managed, to evolve into? To answer this question we must also take into consideration human values and their impact on ecosystems thoughout history.

Learning Lessons from History

The western vision of an untouched wilderness has pervaded through global policies and politics in resource management (Gomez-Pompa and Kaus, 1992). But this view of forests is based not only on an out-moded ecological perspective, but also on a misunderstanding of the historical relationship between people and forests, and the role people have played in maintaining biodiversity in forested habitats. A brief review of certain episodes in the history of people, forests, and biodiversity will show how humans have affected the birth, growth, death, and renewal cycle in a variety of ways, with a variety of outcomes in different parts of the world. The conclusion that the world has few, if any, forests which have not been significantly influenced by cycles driven by people is supported here by evidence from three parts of the world:

Asia. Tropical Asia was one of the

heartlands of shifting cultivation (Solheim, 1972), a repetative pattern of agriculture which has had a profound influence on habitats throughout the region over the past 10,000 years. Shifting cultivators plan their lives on the basis of the cycle of clearing and tilling the land, planting, harvesting, and regenerating vegetation in the uncultivated fields to recover nutrients over the subsequent decade or two before the cycel begins anew. A wide range of crops can be grown in forest fields, transforming a natural forest into a harvestable one which does not necessarily lose diversity on a landscape scale. Among the Lua of northern Thailand, for example, about 120 crops are grown; the uncultivated fields continue to be productive for grazing or collecting, with well over 300 species utilized (Kunstadter, 1970).

Under traditional systems of shifting cultivation, wildlife flourishes. Elephant, wild cattle, deer, and wild pigs all feed in the abandoned fields, and tiger, leopard, and other predators are in turn attracted by the herbivores. The older fields contain a high proportion of fruit trees which are attractive to primates, squirrels, hornbills, and a variety of other animals. Wharton (1968) has provided convincing evidence that the distribution of the major large mammals of southeast Asia is highly dependent on shifting cultivation, because mature tropical forests conceal most of their edible products high in the canopy beyond the reach of the terrestrial herbivores, while forest clearings bring the forest's productivity down to where it can be reached by hungry browsers. The earlier successional stages are also faster-growing, and therefore more productive, than the later stages of the cycle as the forest becomes more mature.

However, the conclusion that shifting cultivation has benefitted both man and forest is dependent on it being carried out in a sustainable manner, which today is becoming an extremely rare phenomenon. Shifting cultivation can be detrimental in at least three main ways: by an increase in human population which causes old plots to be recultivated too soon; by inept agricultural practices such as cultivating the land for so long that productivity declines; and by attemping to cultivate forests which are too dry, so recovery is too slow and the danger of large fires is too great (Geertz, 1963). Sometimes the three factors work together to destroy wide areas of tropical forest.

Most shifting cultivation has taken place in the hills, where the vegetation dries out more quickly and updrafts help fan the flames among the cut vegetation. The lowlands, many of which were seasonally flooded or otherwise difficult to burn, remained relatively intact during the early years of agriculture and were used mostly for hunting, fishing, and gathering of plants. With the development of irrigation and agricultural surpluses all that changed, and new civilzation flourished in lowlands where wet rice could be grown, often leading to substantial forest clearance.

Sumatra, for example, was the centre of the rice-growing Sriwijaya civilization which spread its influence from what is now Palembang throughout southeast Asia, even sending an army to Cambodia in the 8th century AD. Following its collapse in the 14th century, forests quickly reclaimed much of the landscape which had been transformed by Sriwijaya (Schnitger, 1964) and parts of their ancient farmlands are now so important for biodiversity that they are included in Indonesia's protected area system. Even some of Indonesia's most remote protected areas are proving to contain important Sriwijanan archaeological sites, as in Kalimantan's recently-established Kayan Mentarang Nature Reserve, and indication of substantial historical human activity in forests noted today for their high biodiversity.

In Sri Lanka's remote and well-forested Mahaweli Basin, engineers digging the first survey ditches twenty years ago for a major water resources development programme were surprised to uncover ancient irrigation works two metres or so below the surface, but precisely where hydraulics experts advised building irrigation channels. Subsequent investigation revealed that these channels were built some 800 years ago, when Sinhalese civilization flourished in the Mahaweli. It soon became apparent that today's forests were yesterday's rice fields, and that modern development was following in the footsteps of the ancients.

But why were these ancient systems not still in use? Historians say that the hydraulic civilization of Sri Lanka's Mahaweli region had a tumultuous past, with military adventures, social unrest, major investments in religious monuments and irrigation projects, political intrigue, and eventual collapse (Raven-Hart, 1981). The depth of the sediments found by the modern surveyors suggests that an increasing population might have spread into the surrounding hills and cleared the forested uplands for shifting cultivation. This would have led to the increasing levels of siltation that eventually smothered the irrigation systems. Social unrest and political intrigue no doubt accelerated the deterioration of the irrigation systems, and the Mahaweli Basin was abandoned some 600 years ago by the irrigators. Forests reclaimed the abandoned rice fields, the irrigation tanks began to resemble lakes, civilization moved to the northern and western parts of the island, and the aboriginal Vedda inhabitants of the region reclaimed their use rights. Today's developments are beginning the cycle anew, though a system of national parks is being established to help protect the forests and avoid repeating history's mistakes (McNeely, 1987).

Similarly, in what is now Cambodia the civilization centred around Angkor Wat in the 10th to the 12th centuries was based on a sophisticated irrigation system which enabled growing populations to be supported. But the cost of development was the depletion of the forests, leading to disastrous silt loads that came with the floods of the rainy season. The canals became clogged and epidemics of malaria swept through the city, caused by the mosquitoes which bred profusely in the now stagnant swamps. This weakened the capacity of Angkor to adapt to change, and the magnificent capital city was abandoned, leaving the irrigated rice fields to return to forest and the people to return to their age-old hunting, gathering, and shifting cultivation existence (Audric, 1972).

In tropical Asia, forest management was primarily in the hands of the people who lived in the forests in pre-colonial times, but the colonial era brought forests into the global market system, leading to many forests being nationalized, forest management technology being imported from Europe, and the loss of many traditional means of maintaining biodiversity in forests. Poffenberger (1990) points out that conflicts between state land management policies and locally operting forest-use systems is a major cause of forest land mismanagement throughout southeast Asia. Radical changes in tenure rights and lack of clarity over ownership of tree and forest products are key factors in understanding the speed with which Asian forests have been depleted, and why so many species are threatened today.

The Western Hemisphere. Trees played a crucial role in the initial occupation of the western hemisphere. It is now believed that the critical environmental variable that enabled the first humans to move from Asia into North America was the reappearance of trees in Alaskan river valleys, which provided essential fuel sources as glaciers withdrew at the end of the Pleistocene around 11–12,000 years ago (Hoffecker, Powers, and Goebel, 1993). Human influence on forested ecosystems, therefore, began as soon as people moved into the continent.

As they moved further south, the immigrants from Asia continued to modify the American forests. These early immigrants had a significant impact on biodiversity as well, with some 34 genera of large mammals becoming extinct around the time of first human occupation of the continent (Martin and Clein, 1984). On the other hand, selective burning and other forms of forest clearance promoted a mosaic quality of North American ecosystems, creating forests in many different states of ecological succession and thereby promoting biodiversity on a landscape scale.

With the coming of European colonialists in the sixteeth century, the eastern forests were under renewed pressure for agricultural clearance and construction. By 1700 most of the timber within 30km of the main rivers of New Hampshire had been felled and within another 50 years most of the eastern sides of the mountains had been cleared of timber. By 1775, the eastern part of North America had been stripped of the very tall pines needed for main masts of British ships, and the great hardwood forests of the eastern seaboard had lost over 75 per cent of their area by 1880 (Ponting, 1992).

Global trade was a key factor in the loss of forests in the North American colonial period, even if the local people were not always aware of this. The colonial authorities manipulated the process of settlement and forest clearance, with constant collusion between the government authorities and wealtlhy individuals helping to transform the colonial economy (Ponting, 1992).

Further south, many of the tree species now dominent in the mature vegetation of Central America were, and still are, .the same species protected, spared, or planted in the land cleared for crops as part of the practice of shifting agriculture. By AD 800, the Maya had modified 75 per cent of the Yucatan forest, and following the collapse of the classical Mayan civilization shortly thereafter, forest recovery in the central lowlands was nearly complete when the Spaniards arrived 700 years later (Whitmore, *et al.*, 1990). The Aztecs followed a similar cycle. The current composition of the vegetation in Central America thus is the legacy of past civilizations, the heritage of cultivated fields and managed forests abandoned hundreds of years ago (Gomaz-Pompa and Kaus, 1992).

Even further south, the great "pristine" forests of Amazonia supported a human population of at least 8 million people at the time of the voyage of Christopher Columbus (Denevan, 1992a). By 1492, the Amazon forests had been significantly influenced by human use, and the people were managing kinds, numbers, and distributions of useful species of trees. Modern-day tropical forest hunters with simple technology also have significant impacts on the forest, suggesting how even relatively simple technology could have affected forest biodiversity. While routinely hunting and gathering through the forest, the Kayapo Indians of Amazonia collect dozens of food plants, carry them back to forest campsites or trails, and replant them in natural forest savanna, where patches of forest are scattered, areas where collected plants have been replanted form useful food depots for the indigenous people (Posey, 1982). This age-old pattern has had profound effects on the distribution of plants in the forest and has been an important influence on the current biodiversity of Amazonia.

But when European colonists brought diseases, forced labour, and the like, the population of tropical Amerindians crashed, with an estimated 76% of the native people of the Americas south of the present-day USA being eliminated between 1492 and 1650 (Denevan, 1992a). This population crash was not compensated by new immigrants until fairly recent times, leaving wide areas of agricultural land to revert to tropical forests which today are often considered "pristine" or "natural." In short, the authentic primeval forest of the Americas was discovered over 10,000 years ago by the first Asian immigrants, who quickly set about modifying the forest to suit thei r ends. The "virgin forest" alleged to have been found by European explorers in the 16th and 17th centuries, and which has had such a profound influence on global perceptions of tropical rainforests, was in fact invented by romantic writers about nature in the late 18th and early 19th centuries (Pyne, 1982).

Europe and the Mediterranean. The case for Europe is perhaps even more dramatic. The ancient vegetation of the Mediterranean area was a mixed evergreen and deciduous forest of oaks, beech, pines, and cedars. The forest was eaten away by waves of different civilizations who used the forest and forest lands to further their development objectives, expanding and contracting as the wisdom of their policies was tested. The process of forest clearance was already well underway at the time of Homer in the 9th century BC. Civilizations from Bronze Age Crete and Knossos, Mycenaean Greece, Cyprus, Greece, and Rome rose and fell with the forests which supported them (Perlin, 1989). Subsequent overgrazing by sheep, cattle, and goats prevented the forests from ever becoming re-established.

The olive is perhaps the "flagship species" of the Mediterranean. Developed from a straggly wild relative along the coasts of Syria and Anatolia in the 6th century BC, it became a crop of outstanding economic importance. But it also led to significant deforestation, land degradation, and loss of biodiversity. As the richer valley lands were cleared of forests to plant crops, the poorer soils of the hillsides were being planted with olives. The development of Crete between 2500 and 1500 BC was supported by the export of timber and olive oil to Egypt, as forest trees were felled and olive trees were planted. But as a result of deforestation, soil accumulated in a million years was being washed from the hillsides in just a few centuries, and the natural wealth of the country was eroded with the soil. The decline of the Cretan forests was mirrored by the same transformation, following in the wake of the axe, the plough, and the olive in their westward progress through all the civilized states of the Mediterranean (Darlington, 1969). As a result, much of the evergreen forest in the Mediterranean region was transformed into the low-diversity brushwood known as *maquis* which today is maintained by fire. The loss of native forests also had significant impact on biodiversity, with some 90 per cent of the endemic species of mammals of the Mediterranean becoming extinct after the development of agriculture (Sondaar, 1977).

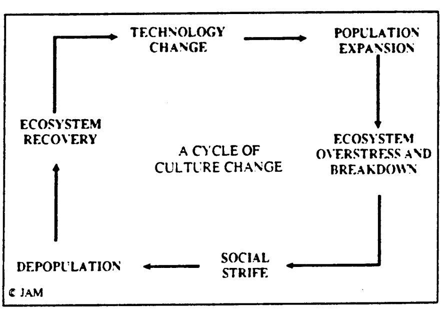
On the Mediterranean north coast of Africa, Carthage, too, suffered from serious deforestation, over-exploiting timber for building ships of war. The soil erosion which followed prevented the restoration of forests and pastures, creating swamps which, beginning in the 3rd century AD, began to harbour mosquitoes which infected North African armies invading Europe with malaria. So it was that, following Crete and Greece and preceding Sriwijaya, Angkor, and the Maya, North Africa took the deforested pathway to the collapse of civilization, at a pace accelerated by war (Darlington, 1969). The forests of North Africa have never recovered, and numerous species have been lost.

Forest clearing has been a significant factor in the history of central Europe as well, where a series of internal colonization movements driven by technological change have had significant impacts on forests. The eighty per cent of central Europe covered by forest around 900 AD had been reduced to just 20 per cent by the time Columbus set sail to encounter the "New World."

The rapid clearing of European forests during times of changing technology caused significant shortages of timber. Portugal's timber shortage may have helped stimulate its voyages of exploration along the coast of Africa and the Indian Ocean and by the 16th century nearly all Portuguese ships were built in its colonies. Spain suffered similar shortages, buying trees from Poland to build the Spanish Armada. The English navy, which ruled the seas and enabled the vast British colonies to be governed in the 18th and 19th centuries, was built only partly from British oaks; significant amounts of timber were imported from Scandinavia and Russia (including 600,000 trees a year from Russia to supply the Royal Navy in the late 1750s) (Ponting, 1992).

On the other hand, the loss of forests also challenged people to be creative. In England, for example, forests had been so reduced by the early 16th century that fuelwood was replaced by coal, stimulating new methods of manufacturing and the exploitation of new resources. The loss of forests was therefore an important stimulus to both the industrial revolution and the colonizing impulse of Europe (Nef, 1977). By the 19th century, serious shortages led to timber being considered the most important forest product, and foresters developed a value system that focused on issues of engineering and biological productivity, with relatively little attention given to questions of broader social interest and social values, including biodiversity. European (mostly German) foresters then promoted the single-use forestry model to North America, Australia, New Zealand, Japan, and India (Behan, 1975), thereby having a profound influence on forests and their biodiversity throughout the world.

These three brief histories of some aspects of forests and biodiversity lead to the general conclusion that the impact of humans is not simply a process of increasing change or degradation in response to population growth and economic expansion. History is instead interrupted by periods of reversal and ecological rehabilitation as cultures collapse, populations decline, wars occur, and cultivated habitats are abandoned to forests. Impacts may enhance or reduce biodiversity, but change has been continual at variable rates and in different directions (Denevan, 1992b). It is also instructive to compare these historical cycles with the ecological cycles described earlier. Perhaps the development of new technology is comparable to "birth," while the rapid exploitation of forests following the new technology can be seen to fuel a rapid "growth" in the human culture. As exploitation accelerates, a point of over-exploitation is reached ("death"), the human population declines, the forest recovers, and the human culture adapts to the new conditions ("renewal"). In some cases, such as Europe, the renewal leads to significant technological changes, while in others it may lead to a return to living in a new balance with the forests (as in Amazonia), while in still others it may lead to cultures which have essentially lost their links to the forest (as in Easter Island or North Africa).



Four Cultural Revolutions

Forests have been an essential basis of human prosperity, providing diverse products and services throughout the evolution of our species. The combination of cyclical ecological and historical factors goes a long way toward explaining which of the many goods and services available from forests will be given priority by a society, the means available to utilize these resources, and the impact human decisions have had on biodiversity and on sustainable productivity. Clearly, what is acceptable under one set of socio-economic and ecological conditions—or level of understanding—may be totally rejected under another set of conditions (Maini, 1992); but at each period in history, society may be seen to be acting in its perceived self-interest. As we have seen above, civilized society has not always been "right" in its judgement, if we equate "rightness" to sustainability. The ruins of civilizations past bear ample witness to miscalculations in the development strategies of our forebears. Nor are traditional societies always wise stewards of biodiversity, judging from the many prehistoric extinctions which appear to have accompanied early hunters and agricuturalists (Martin and Klein, 1984).

Drawing on the earlier discussion, numerous cultural innovations can be seen to have affected human impacts on forests, of which as least four have been revolutionary: fire; agriculture; technology; and trade. Each of these revolutions has been supported by numerous specific innovations over time (e.g., iron, chemical fertilizers, computers, nuclear power), but fire, agriculture, technology, and trade have each brought very fundamental changes to the relationship between people and forests, drawing from technological innovations and stimulating change in different ways.

Fire. Controlling fire enabled early hunters to burn grasslands and open forests, thereby increasing the productivity of these habitats, attracting the large species humans preferred to hunt, and facilitating the movement of hunters. Fire subsequently became an important tool for clearing land for agriculture, and for converting biomass into energy useful to humans. The use of fire (combustion) to convert fossil fuels to energy—essentially drawing on hydrocarbons stored by living organisms long extinct—is now elevating atmospheric carbon dioxide and is highly likely to lead to significant climate change (Schneider, 1989), thereby affecting the climatic cycle and causing fundamental changes in forest types and distribution.

Agriculture. Agriculture fundamentally changed the relationshiop between people and the rest of nature through domestication of plants and animals, which enabled a much greater degree of human control over some ecosystems, species and their genetic composition. Traditional farmers modified species to meet their needs, leading to greatly enhanced genetic diversity among the species cultivated; India, for example, had over 25,000 varieties of rice. Based on archaeological evidence and historical records, it seems certain that the early agrarian societies were highly dependent on forests as an essential supplement to their permanent fields, providing both goods (nuts, fungi, wood, fodder, firewood, medicinal plants, etc.) and services (building soils during fallow periods, protecting water sources, etc.). This pattern has continued until the present in many agrarian systems. Agricultural land has spread at the expense of forests but this has often been a cyclical change and even today agricultural land covers only about 10 per cent of the terrestrial surface of the planet (WRI, 1992). Many agricultural systems have maintained great biodiversity: Javanese farmers, for example, cultivate over 600 species in their gardens, with an overall species diversity comparable to deciduous tropical forest (Socmarwoto, 1985). But in recent times, the "green revolution" has led to a loss of genetic diversity and a reliance on energy (in the form of fertilizers, pesticides, etc.) from outside the system. Modern biotechnology will undoubtedly lead to additional changes, but limits are being reached.

Technology. While tool use is not unique to our species, we have developed it in such a way that it enables us to harvest a much broader spectrum of nature's products than any other species (Gibson and Ingold, 1992; Kingdon, 1992), and indeed technology has played an important role in our evolution (Schick and Toth, 1993). Judging from both archaeological and historical evidence, technology has been characterized by change. When technological change is very rapid, over-exploitation is to be expected as traditional controls break down and humans learn to exploit resources in new ways. Modern technological innovations—such as plantation forests or industrial logging—tend to favour over-exploitation of forests and the weakening of traditional approaches to forest management. Today, technology—through processing, transport, and marketing—enables the global consumer society to harvest resources from alternative locations when local resources are exhausted. The market-driven economy derives no particular advantage from adopting the traditions of sustainable, conservative use that may have characterized the groups which lived in balance with their resources, instead feeding most of the benefits of the forest into the global system while paying few of the local environmental costs. These costs remain with the local people, who must live with the consequences of the resource management decisions imposed upon them from outside (Gadgil, 1987).

Trade. Trade has been an important part of all civilizations and enabled far greater populations to be supported. With trade, forests no longer support only the local human ecosystem, but increasingly feed the demands of distant markets. International trade makes forests part of the international economic system rather than the national or local economic system, so costs and benefits of timber production are distributed in ways that are quite different from locally-marketed or subsistence commodities. Timber has become a major commodity in international trade, with the top ten exporters earning some US$70.7 billion in 1989 (FAO, 1992), of which developed countries accounted for over 81 per cent. Because they are not responding to local conditions of supply and demand, traders do not experience the limits which agrarian forest managers learned to address through management systems developed over long periods. Although trade allows some countries to live beyond the ecological carrying capacity of their borders, it is impossible for all countries to do so. As Daly (1992) has pointed out, no matter how much world trade may expand, all countries cannot be net importers of raw materials and natural services. Free trade might allow the ecological burden to be spread more evenly across the globe, thereby buying time before facing up to the limits, but at the cost of eventually having to face the problem simultaneously and globally rather than sequentially and nationally (or even locally) (Daly, 1992). Trade converts the world's forests from a complex set of multiple cycles operating at different speeds in different parts of the world into one massive inter-connected cycle. What were once locally self-sufficient and sustainable human systems have become part of much larger national and global systems whose higher productivity is both welcome and undeniable, but whose long-term sustainability is far from proven. Furthermore, increased consumption facilitated by this higher productivity is also encouraging land-use practices which are unsustainable, especially deforestation and use of land for agriculture that would be more suitable for forests or other uses. As demonstrated by the experience of previous civilizations and the seemingly inevitable cyclical changes that are inherent in forest systems, this all-or-nother approach is a risky strategy.

Conclusions

The general trend is clear: human influence on forests has increased significantly over time, as those responsible for managing forests have responded to the social values of the time. Innovations for gaining more benefits for people from the planet's finite resources increase the availability of food and thus determine local growth of population, leading to migration to relieve population pressure and repeating cycle of expanding population and improving technology (Cavalli-Sforza, Menozzi, and Piazza, 1993). While local civilizations and cultures undoubtedly have gone through cycles, the global trend is still toward greater human dominance of the world's ecosystems.

What, then can we expect of the future? Changed circumstances are bringing about new perceptions and new demands. The recognition of the role of forests in climatic, nutrient and other cycles, will stimulate new approaches to forestry. Forest economists perceive the quantifiable economic value of logs from a rare old-growth forest very differently from the non-quantifiable social values reflected in political decisions. One of the challenges inherent in a multiple-use approach is that those outputs of forests that can be allocated by markets are relatively easy to quantify and exploit, while those that cannot be given a market value—such as biodiversity—tend to be undervalued and are therefore likely to be degraded over time. Utilitarian values are often in conflict with strongly-held romantic and symbolic values. To many urban people today, clearing rare old-growth forests for their commodity values is as sensible as melting down the Eiffel Tower to sell the iron to make more automobiles. The controversy in the Pacific Northwest of the USA and Canada between loggers and advocates for the spotted owl is simply one example of the political process of making choices about how forests are to be managed. As non-product benefits like biodiversity become more important to urban citizens, the social system (such as public interest groups) and the political system (including new legislation, regulations and reorganization of forestry agencies) inevitably will become a more prominent part of forest management (Kock and Kennedy, 1991).,

Where the forest industry once exploited a seemingly endless timber supply, political demands for sustainability are forcing it to seek maxi.mum benefits out of a smaller quantity of higher quality wood, or out of lower quality second growth and plantations. Foresters are increasingly seeking combinations of forest uses which are compatible. They are finding, for example, that conserving biodiversity and indirectly regulating climate are highly compatible forest services, and that such uses can also allow the production of non-timber forest products, the conservation of soil and water, and recreation and tourism. These uses are certainly incompatible with clear-felling, but perhaps may be compatible with well-managed selective logging. The trend is clearly away from single-product forestry, and back to diversity and benefits for people living in and around the forests. Ecological science supports this cyclical change away from clear-felling for chips or timber and toward a more sensitive and diverse approach to forest management. Since ecosystems are dynamic, with multiple futures that are uncertain and unpredictable, forest management must itself be flexible (Schindler and Holling, in press).

It appears that the best way to maintain biodiversity in the late 20th century is through a combination of strictly-protected areas (carefully selected on the basis of clearly-defined criteria), multiple-use areas managed by local people, natural habitats extensively managed for sustainable production of commodities such as forage of logs (but with other benefits being accommodated to the extent possible), and agricultural land and forest plantations intensively managed for the consumer products needed by society. This diversity of approaches and uses will provide humanity with the widest range of options—the greatest diversity of opportunities—for adapting to the cyclical changes which are certain to continue.

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The George Wright Society was founded in 1980 to serve as a professional association for people who work in or on behalf of parks and other kinds of protected areas and public lands. Unlike other organizations, the GWS is not limited to a single discipline or one type of protected area. Our integrative approach cuts across academic fields, agency jurisdictions, and political boundaries.

The GWS organizes and co-sponsors a major U.S. conference on research and management of protected areas, held every two years. We offer the FORUM, a quarterly publication, as a venue for discussion of timely issues related to protected areas, including think-pieces that have a hard time finding a home in subject-oriented, peer-reviewed journals. The GWS also helps sponsor outside symposia and takes part in international initiatives, such as IUCN's Commission on National Parks & Protected Areas.

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George Melendez Wright (1904-1936) was one of the first protected area professionals to argue for a holistic approach to solving research and management problems. In 1929 he founded (and funded out of his own pocket) the Wildlife Division of the U.S. National Park Service—the precursor to today's science and resource management programs in the agency. Although just a young man, he quickly became associated with the conservation luminaries of the day and, along with them, influenced planning for public parks and recreation areas nationwide. Even then, Wright realized that protected areas cannot be managed as if they are untouched by events outside their boundaries.

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