Protecting Biological Diversity in the National Parks: Workshop Recommendations

Edited by:
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PROTECTING BIOLOGICAL DIVERSITY IN THE NATIONAL PARKS: WORKSHOP RECOMMENDATIONS

May 3–5, 1988
Great Smoky Mountains National Park
Gatlinburg, Tennessee 37738

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As the Nation's principal conservation agency, the Department of the Interior has responsibility for most of our nationally–owned public lands and natural and cultural resources. This includes fostering wise use of our land and water resources, protecting our fish and wildlife, preserving the environmental and cultural values of our national parks and historical places, and providing for the enjoyment of life through outdoor recreation. The Department assesses our energy and mineral resources and works to assure that their development is in the best interests of all our people. The Department also promotes the goals of the Take Pride in America campaign by encouraging stewardship and citizen responsibility for the public lands and promoting citizen participation in their care. The Department also has a major responsibility for American Indian reservation communities and for people who live in Island Territories under U.S. administration.

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Contents

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May, 1990

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Editors

EDITORS' NOTE:

Mr. Vern Hippensteal's pen and ink drawings, featured on the cover and in the text, depict some important examples of the rich biological diversity native to Great Smoky Mountains National Park and the surrounding southern Appalachian region.

Abstract

A workshop was held in May 1988 to develop recommendations for perpetuating and enhancing biological diversity in the parks of the National Park System. Workshop participants included selected university scientists, National Park Service administrators, scientists, and resource managers, and representatives from the National Science Foundation, the Office of Technology Assessment, the U.S. Fish and Wildlife Service, the U.S. Forest Service, and the Canadian National Parks Service. This report synthesizes the discussions and recommendations of the workshop.

Two keynote addresses were presented at the beginning of the workshop: one by a university scientist, Dr. Dan Goodman, and the other by a National Park Service manager, Mr. Boyd Evison. Dr. Goodman proposed a general framework to bring the Park Service's policy and science complex together to enhance conservation biology in the national parks. Mr. Evison suggested that great care should be taken any time we consider modifying an ecosystem, and that cooperative efforts are needed to develop adequate inventory and monitoring systems in the National Park Service.

Six working groups then convened to address the following subjects: management policies and issues, inventorying and monitoring, viable populations, human disturbances, dynamic processes, and integrating parks into larger units. Each group refined its issue and developed specific recommendations for the National Park Service. The most general problems defined across all groups included (1) lack of adequate knowledge and understanding of biological processes; (2) the increasing isolation and fragmentation of park areas; and (3) the lack of continuity in research and resource protection activities. Although many specific recommendations were developed, several common themes that emerged included the need for (1) more emphasis on ecosystem management; (2) cooperative approaches to protection, research and education; and (3) policy and/or legislation establishing protection and restoration of biological diversity as a priority of the National Park Service.

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"The most ubiquitous and irreversible environmental problem facing the planet is the loss of biological diversity. Species extinction is occurring at a rapidly accelerating pace because of population pressures and a pervasive lack of understanding of what is at stake. If current trends continue, the earth will lose a large share of its species within our times.

Americans have one last opportunity during the next few years to protect a significant portion of our own biological wealth through careful scientific management of the Federal lands, which constitute almost one-third of our national land base. But without fundamental changes in the management of our national forests, parks, wildlife refuges and BLM lands, our nation will needlessly lose large numbers of species, genetic diversity and entire ecosystems."

-Gaylord Nelson, The Wilderness Society

Introduction

The protection of biological diversity within U.S. national parks has been recognized in recent years as a vital component of the mission of the National Park Service (NPS). A careful reading of the enabling legislation--both the 1916 Act establishing the National Park Service and legislation creating individual parks-- suggests that human uses of parks must not occur at the expense of natural features and systems, including their inherent biodiversity.

Biological or ecological diversity has been defined as the variety and abundance of species in different habitats and communities. The continuum of biodiversity ranges from the broad biogeographical level to the subcellular/molecular scale. For the NPS, three levels of organization are particularly important: *ecosystem diversity* (habitats, communities, and dynamic processes); *species diversity* (numbers of individual species of plants and animals); and *genetic diversity* (diversity found within species). Through its mandate to protect resources unimpaired for future generations and its policy of ecosystem management, the NPS is charged with protecting biological diversity at all of these levels.

Despite this implicit mission to conserve biological diversity, some units within the National Park System either have lost, or may be losing, populations of species from their original, pre-colonial flora and fauna; some parks contain highly disturbed or degraded ecosystems. Without additional habitat acquisition or management actions, native species or their populations may be lost from individual parks at an accelerating rate in the future.

If national parks have had at least an implicit mandate for some 75 years to protect biological diversity, why is biodiversity in the parks now at such risk? What can be done to reverse the situation? These were the questions at the heart of the workshop on biodiversity in the U.S. national parks, held in Gatlinburg, Tennessee, in April, 1988.

The workshop brought together university and federal government scientists actively working in conservation biology, National Science Foundation (NSF) administrators, and NPS managers to discuss the problems associated with preserving biological diversity in the U.S. National Park System. The objectives were to:

1. Facilitate communication and interaction between scientists, resource managers, and administrators;

2. Produce recommendations based on this interaction which would define opportunities, constraints, and informational needs vital to the maintenance and enhancement of biological diversity in units of the National Park System;

3. Encourage a programmatic emphasis by the Directorate of the NPS on a Service-wide focus on conserving biological diversity; and

4. Encourage NPS research scientists and resource managers to develop cooperative programs with the involvement and support of key professional societies, such as the Society for Conservation Biology (SCB) and the Ecological Society of America (ESA), and professional research institutions, such as the National Science Foundation.

Participants at the workshop were divided in working groups consisting of three or four non-NPS scientists and three or four NPS scientists and managers. Each group was charged with addressing a different, but sometimes overlapping, component of the problem: (1) management policies and issues, (2) problems of inventory and monitoring of biodiversity, (3) the concept and implications of "viable populations," (4) human disturbance factors, (5) the role of dynamic system processes, and (6) the place of national parks within a larger land-use context.

During the workshop, each group reviewed the state of current knowledge on their particular topic and discussed how current NPS policies and constraints relate to the implementation of present or future plans for the preservation of biological diversity. The NPS managers contributed their experiences on specific issues related to the general topic. The group also made recommendations for relevant research in its particular topic area. This information was summarized in written statements prepared by the group leaders.

Each group leader then made a brief presentation to the workshop as a whole. After this critique, the group prepared a final written statement. The group leaders presented their final statements to NPS officials and obtained their input. Finally, the facilitator presented a "capstone" report to all workshop participants and solicited final comments from them.

Problems in Protecting Biodiversity

Common threads woven throughout the six sessions reveal at least some of the reasons why protected areas, specifically U.S. national parks, are failing to adequately protect biodiversity within their borders. Chief among these include:

1. *Lack of adequate knowledge and understanding.* Before biological diversity can be protected adequately, the NPS must know what it has in the areas under its control, and what processes are at work. Yet existing data bases are inconsistent and incomplete, and procedures for inventorying, measuring, and monitoring biodiversity are inadequate. Furthermore, those NPS procedures that do exist are often incompatible with those developed by other public agencies, making transfer of knowledge across agency lines difficult or impossible.

There is inadequate knowledge not only of species diversity itself, but also of the requirements for population viability. Knowledge of the dynamic processes underlying ecosystem function is also insufficient. There is a lack of understanding of the historical processes that have been at work within various parks and regions, and a lack of knowledge of and monitoring procedures for events and processes outside park boundaries.

2. *"No park is an island."* Because park boundaries generally were not set on the basis of functioning regional ecosystems, biological diversity within parks often depends on maintaining nearby populations and habitats outside the park borders. Many species likely to be lost from parks are migratory, or have large home ranges, requiring appropriate available land outside park boundaries. In many cases, parks cannot by themselves maintain genetically viable populations without some interbreeding with populations external to the parks. Perhaps most importantly, all species within artificially defined park boundaries depend on water, air, and other critical resources that are part of a wider landscape picture, which is both regional and global in scope.

Ironically, while no park can function as an island distinct from its surroundings, all parks are becoming increasingly isolated--encroached upon by human activities and fragmented into "habitat islands." Inadequate research and management coordination between parks and their neighbors pose immediate threats to the integrity of biodiversity within the parks.

3. *Continuity.* Consistent, sustained funding has not been available for critical research, inventory and monitoring procedures, habitat acquisition, restoration and recovery efforts, and other activities vital to the protection of biodiversity in national parks. Some conference participants attributed this lack of financial support in part to a legislative inadequacy that leaves the protection of biological diversity in the limbo of being an implied rather than an explicit mandate for national park management.

Recommendations

Participants in each of the six sessions proposed a set of policy and research recommendations specific to the question at hand. Again, common threads appeared over and over in all sessions, revealing the essential changes in attitude, policy, research, and management that must take place if biological diversity within our National Park System is to be protected.

First among these is a critical need to begin thinking about parks and their biodiversity in a wider context--emphasizing ecosystem-level management as part of a larger national conservation strategy whose aim is the survival of biodiversity. This is becoming ever more crucial in the face of global environmental influences such as climatic warming and will require national leadership in the years to come.

Second, truly protecting biodiversity within national parks and the nation will require innovative, interagency, cooperative approaches for obtaining and sharing knowledge and technical skills, and for developing coordinated research, education, and management programs in a regional context. Integrated regional inventories and coordinated long-term monitoring of biological diversity are essential. Public awareness and education will also play a vital role in stimulating understanding and support for biodiversity protection.

Third, recognizing that parks represent but samples of natural biological diversity, conserving America's biodiversity will require paying attention to habitat considerations, such as the need for multiple sites and occasional physical linkages between them. It must be recognized that the chances for a population or species to survive in an area depend not only on the size of the population, but also on the amount, quality, and distribution of habitat and on the kinds and degrees of various pressures put upon the species.

Finally, specific legislation is needed to formally mandate the long-term protection and/or restoration of biodiversity as a formal priority for the National Park Service. This step would pave the way for sustained and adequate funding for both research and management, and provide new incentives for park managers to direct their attention and activities to the problems and protection of biodiversity in the national parks.

In addition to the opening remarks and keynote addresses, the six sections that follow provide details of the discussions of each of the six conference work groups. Each section includes the names of the participants, a summary of the problem addressed, and the recommendations proposed by the group. References are included for other sections which proposed the same or similar recommendations.

The first three sections--Management Policies and Issues, Inventory and Monitoring, and Population Viability--focus more on within-park components of the biodiversity problem, though all also have implications beyond park boundaries. The next three sections--Human Disturbance, Dynamic Processes, and Integrating Parks into Larger Units--look more deliberately at the larger context and the specific influences from outside a park boundary that affect its biodiversity.

The concluding summary lists the merged recommendations from the entire conference, arranged by topic and marked with references to the section(s) in which they were proposed.

"The Moon and the planets will be out there forever, but the Earth's biological diversity is being exterminated now. It is therefore imperative that we study and carefully preserve nature on this planet now, for this will be our last chance to ensure that biodiversity will survive for future generations."

-Hugh Iltis, in *Biodiversity*, E.O. Wilson, ed.

Welcome Address

Robert M. Baker
Regional Director
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During the Civil War, at a Union hospital not far from the Great Smoky Mountains National Park, scores of wounded Federal soldiers and Confederate prisoners were taken for care. Medical supplies were limited. Especially scarce were chloroform and lint, which were used to keep maggots out of open wounds. Obviously, at a Union hospital the limited medical supplies were used to care for the Federal soldiers; Confederate doctors were given virtually no supplies. Inevitably, the soldiers in grey became infested with maggots.

But a strange thing happened. The Southerners healed faster than the wounded Northern soldiers. Even the rooms where the Southerners were housed smelled fresher and seemed healthier than the Yankee sick rooms.

The Southern doctors had stumbled onto a great discovery: maggots can be useful in stopping the growth of bacteria and in keeping wounds clean.

This same phenomenon had been noted by a French surgeon during the Napoleonic War, but his findings had been ignored. The Union doctors, disbelieving the obvious, continued to treat their patients with chloroform and lint with a resulting higher casualty rate.

Why would I share this story at a Conference on Biological Diversity? I think it touches on three very important points for us:

1. *The importance of communications.* In this story, "no treatment" was superior to "the recommended treatment;" yet the physicians were not aware of the discovery by the French doctor during the Napoleonic War. Perhaps he published in the wrong journal. But seriously, what other medical knowledge was known

somewhere in the world in the 1860's that may have offered better treatment and saved lives? With the proliferation of knowledge in today's world, we all have a major task in communications. This conference offers us a tremendous opportunity to shape what we know and understand about biological diversity. Also, let's be sure that what we do here this week is shared in the "right journals."

2. *The value of lower life forms.* The maggots helped save lives. Too often when I hear discussions on biological diversity, I hear concern only for those highly visible species at the top of the food chain. This conference will give us the platform to address the importance of an array of life forms.

3. The third point from the story that I want to make is: *Discovery of new knowledge without a commitment to use that knowledge falls short.* The Union doctors were resistant to change. I appreciate the difficulty involved in change and the uncertainties that go with change.

In last month's *American Scientist,* I read the article on "Global Change" by William Hively. He discussed many of the familiar issues that we face: warming from the greenhouse effect, acid rain, destruction of forests, erosion, pollution, species diversity losses, the "ozone hole" over Antarctica, population growth, and so forth. He spoke of new disciplines and the breaking down of traditional barriers that have compartmentalized study. He quoted Dr. Michael McElroy: "Narrow specialists will not solve the problems; neither will shallow generalists." We hopefully have specialists in this room that are not narrow and generalists that are not shallow.

We have a number of our key park managers with us for this conference. They have stewardship responsibilities for some of this nation's most outstanding lands and natural resources. At this conference, we want to "set in motion" a process that will answer the question, "How must we change?" We need each other to be successful in this important undertaking. It is a collective commitment that is essential.

In conclusion, I want to publicly recognize and applaud you and the organizations you represent for your commitment to this effort. To me, it is much more than just a conference. It is an opportunity for an extremely important endeavor to broaden commitment and pursue action.

Finally, I want to say a personal thank you to Dr. Frank Harris of the National Science Foundation for all of us. The proud heritage of the Foundation over nearly 40 years of its existence has meant a great deal to basic science, to the development of human resources, and in providing leadership to help support critical forums such as this. We need your continued support and commitment as we move forward.

Thank you.

Keynote Address: Research

Dan Goodman
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The position I occupy on the schedule is a little bit ominous in that the notion of having a scientific keynote speaker and a policy keynote speaker seems to imply that you can usefully separate them. I don't believe that's true in the present context. We're dealing with an applied question, namely how to manage biodiversity. And an applied management question doesn't allow the luxury of saying "Well, here's something we can deal with strictly as a scientific issue; here's something we can deal strictly as a policy issue." They're intertwined; they're inseparable. And the only way we make progress is by understanding the intersection where good science and good policy meet.

We can understand this by considering the alternatives. Imagine a situation where science has absolutely irrefutable evidence to determine some policy, but there doesn't exist a procedural structure, based on administrative and legal foundations, to implement it. The scientist might just as well be crying in the wilderness. On the other hand, we could develop a brilliant procedural system, that was extremely clever in its checks and balances, reports, flow charts and chain of command. But if this procedural system is triggered by information that science can't provide, then it's never going to be used.

Further, if the system is going to work--the system of administrative and procedural structure--its factual grasp of what the problem is and what the solution is going to be has to be reasonably correct, or it's a catastrophe.

This leads me to propose that there are perhaps five essential features necessary at this juncture between science and policy, if the system is going to work. The first condition is credibility. We can't be perceived to cry wolf as to what the problem is. We must have credibility in our portrayal of what the consequences will be of action or inaction. Our description of what the problem is has to be credible. It has to be based on sound science on which there is a consensus, and which is accessible to public review. A few people screaming "The sky is falling" aren't going to have an impact.

The second feature is also a credibility feature. We have to have credibility in the proposals for the interventions that are being suggested. We say, "Here is what the problem is, and here are the kinds of measures that could be implemented to do something about it." Not only does the portrayal of the problem have to be credible, the portrayal of the solution, the intervention, has to be credible. In the absence of this credibility, no matter what regulations, or even legislation, get put on the books, it's not going to work because at some level this is a contentious society, and in the absence of credibility, the clamor for delays and exemptions will be overwhelming and will paralyze Congress, the courts, and the enforcement structure. We've seen enough evidence of that.

The third feature that's necessary is unambiguous criteria. When someone says, "Here are some possible problems, here are the possible solutions. We could implement them when the time is appropriate," there needs to be an extremely clear notion of the circumstances that should trigger those actions. These criteria will make implementation something other than a haphazard game of discretion. Administrative discretion is not a good thing. It sounds like a good thing to the administrator, but when you think about it, it's the situation where the administrator gets torn to pieces by opposing constituencies, each of which has a different idea of what should be done. All of them lobby the administrator, so it's a bad situation. You need more or less mechanical procedures for triggering action. Procedures have to be based on information that is readily accessible and upon which people can agree. In the absence of these unambiguous criteria, dispute settlement and conflict resolution will be extremely protracted and costly.

The fourth feature is the burden of proof. This sounds extremely legalistic when one is not dealing in the context of scientifically driven policy leading to a court case, but in fact clear-cut burden of proof requirements can help reduce the probability of litigation. The burden of proof issue arises in the connection with what we will call default values. A burden of proof feature is a statement that when there is uncertainty as to what we should do, here is an automatic way we resolve the decision in the presence of that degree of uncertainty. Just as in criminal law, the burden of proof is "innocent until proven guilty." In environmental law, for it to be effective, for any given legislation, or law, there has to be a presumption as to which way a jump shot will be decided in the absence of sufficient evidence for that decision.

The fifth and related feature is a standard of evidence. The standard of evidence requirement is a statement of how much evidence and what degree of certainty is adequate to call the decision something other than a jump shot which is decided by the default rule. How much data do we need, how narrow do the confidence limits on that data have to be in order to use data as the basis of action rather than our default presumption.

These two features together constitute the incentive structure for gathering adequate data. In the absence of these two features, the system would be happy to get along with no data, unpredictable data, or unreliable data; and it fosters attempts to make decisions as the need arises, on a case-by-case, ad hoc basis using information that will be an embarrassment when it is examined.

I'm going to propose this as the general framework, or set of criteria that I'd like to see our policy and science complex develop in the matter of conservation biology as an application to biodiversity issues, particularly in the national park lands.

The national park lands pose an unusual problem for management. The first interesting feature about the National Park System from the standpoint of conservation biology is that the Park Service owns the islands, but the ocean belongs to everyone else. We will have to recognize that as an important matter to take into consideration. What kind of actions, what kind of maneuvering does the National Park Service have in the matter of biological diversity?

The second unusual feature of the Park Service system is that on its own "islands" a very high level of protection is already the rule rather than the exception. So it isn't a matter of persuading the agency to be more protective; it is almost as protective as it can be already. In fact, one of the problems we will have to face occasionally is persuading the Park Service to intervene more in active management in specific cases rather than assuming that it is always best to just let nature take its course.

Which is to say there is a problem of justifying intervention on the part of the National Park Service.

Now in the matter of facing the problem of the "island" nature of the National Park Service, we can say, "Well, that's the way it is, we can't go any further." That's not true. There is every opportunity for useful dialogue with other agencies and the private sector as to how the lands surrounding these national park "islands" should be managed in order to preserve biodiversity in the system as a whole. It is a mistake to think about managing these islands in isolation. Very often these islands will be insufficient for our purposes. It is necessary to develop a system of managing the surrounding lands in a way consistent with management in the parks in order to achieve our goals. Probably the real administrative key to initiating and enforcing that dialogue is going to be what we call population viability analysis.

It will be necessary to see to it that what we are calling a population viability analysis is enmeshed in a scientific and administrative network that satisfies all five criteria for a successful intersection of science and policy. And only then will the population viability analysis serve as an adequate tool for saying we are going to have to change certain practices in land use management around the parks in order to achieve our goals. If we don't change our practices, things are going to happen to change the population in the park, as well as outside the park, that are not consistent with the National Park Service's goals. The population viability analysis is going to have to have credibility in terms of being able to say that yes, the population viability analysis can predict probable extinctions unless we do something about it. It has to have credibility in terms of describing appropriate interventions. For example, "If we proceed with present activities, this population will go extinct in the park; but if we set aside a certain amount of additional acreage outside the park and manage it in this way, there is reasonable assurance that the population will not go extinct." So those predictions have to have credibility.

There has to be a clear criterion as to when a population is or is not in trouble by the standards of the population viability analysis. Here we get to an interesting problem as to whether we are talking about a policy call or a scientific judgment. The first issue we're going to have to address in our criterion for action is: What is a realistic objective for management of populations in the interest of preserving biodiversity? We can't say zero probability of extinction--every species lasting forever--because that just doesn't happen. It's not how nature operates and it's certainly nothing that we can achieve with limited information and resources. There's going to have to be a statement as to how secure a population must be for us to presume viability even though that stops short of guaranteeing its survival forever. This is the place where the scientist has to tell the policy-makers that 100% certainty of a species lasting forever is not possible. We must retreat to a quantitative, probabilistic statement, and then stick with it. There is going to have to be a policy call that a viable population, for example, is a population that has a 99% probability of lasting at least another 1000 years. A scientist can't settle what this number should be as a goal, because it is not a scientific question. It is just a matter of stating what your goals really are.

It's a policy call. It will have to involve many agencies in Washington. It's going to require consensus that the people who adopt it will have to stick with it, because if everyone is using a different number as to what the threshold is for population viability, then implementation becomes haphazard; they're not applying the same standards. So this is an obvious matter on the agenda for the future of all interested parties, to begin to encourage development of consensus regarding a policy call on what is the magic number that we will accept as a population that is adequately viable. If the number comes out less than this, we'll say that triggers the determination that this is an endangered, threatened population. If its viability comes up larger than that magic threshold, then we'll say, yes, this is a viable population.

So, one important matter on the agenda is developing the criteria for a threshold level of acceptable probability of survival. We have to educate the policy people away from the notion that this is going to be 100% survival forever, because that just doesn't make scientific sense. That's like trying to square the circle.

Further down on the list: What are we going to do about burden of proof and standards of evidence in a population viability analysis? In order to view this matter we are going to have to step through the scientific procedure of a population viability analysis as it now exists. How does one go about assessing the viability of a population? Let's take it as given that the output of a population viability analysis is a prediction of the life expectancy of the population being assessed. It's a prediction, for example, of what the mean life expectancy of the population would be if conditions continue as they are at present. Which means sort of a half-life. The mean time to extinction of a population may be 5,000 years. To phrase it another way, the probability that this population will survive at least a thousand years might be 95%. It is the probability of survival to a particular time expressed in one way or the other.

This output is already usable for management purposes. When scientists do their probability analysis, and come up with this number, this is a number that should make sense to the administrative system as giving them a scale on which they can compare which populations are more threatened and which populations are less threatened. Management interventions are more or less efficient at increasing the survival time of a population.

The steps a scientist has to go through in carrying out a population viability analysis are essentially four-fold. First, we need the census, which is the appraisal of how many individuals are there. Theoretically it is unproblematic; in practice it can be a terribly difficult challenge in the case of wide-ranging animals and highly dispersed creatures. In practice it is quite a chore even though theoretically it is no mystery. What is less of a mystery is how to deal with the uncertainty arising because of the limitations of resources and the methodology in conducting the census. Which is to say there is a matter of statistics. In a census, it isn't just the number, it is also the confidence intervals on that number. With a census of plants or animals you don't come out with an exhaustive count of how many are there; you come out with an estimate. And that estimate includes an uncertainty range. That uncertainty range has to be taken into account very carefully, as that uncertainty propagates through the rest of the analysis. So it's not something that can just be swept aside and say we've got "x" for our census, and afterwards call in the statisticians, who will tell us what the confidence limits are, and everything will be okay.

The second component of the population analysis is going to be the deterministic demography. This is a classical, standard type of demography that can be found in textbooks. Many of you are no doubt familiar with it. It consists of creating estimates of the life table of the population in question. What are the birth rates on the average, age class by age class? What are the mortality rates on the average, age class by age class? And perhaps the notion of how these rates vary with the degree of impact and the supply of resources. This deterministic demography, if carried out correctly (and that's a big if), comes up with a prediction whether the population is increasing or decreasing and by how much. Here we see how crucial these questions of statistics (which seem to be swept under the rug in the census) can be, because a few percentage difference in your estimates of these rates might make the difference between saying you have a population which is increasing 2% a year versus a population which is decreasing 2% a year. If you have a population that is increasing 2% a year, soon we'll be knee-deep in them. If you have a population that is decreasing 2% a year, you'll be out of them for all practical purposes in less than a century.

That is why we have to be extremely professional in how we use our statistics in assessing deterministic demography. Because tiny differences in numbers lead to qualitative differences, diametrically different conclusions about what's happening to these populations. If we have a population that is declining, and we have an estimate of rates that tells us that it's declining, we don't have to go any further in seeking mysteries as to what kind of management intervention is necessary. It's necessary to arrest the decline.

If, however, the population is not declining or if the decline under present conditions is related to easily understandable circumstances, we may want to consider alternate scenarios. For example, what if we know that the habitat of this crucial resource is being lost at the rate of 5% per year? Then we wouldn't be astonished when we discover the population is declining something like 5% a year. But we wouldn't like to project that 5% per year decline into the indefinite future if we know as a matter of policy and regulation that the loss of habitat is going to be arrested. And then the amount of habitat protection will have a positive effect. That means that when we use our deterministic demography, not only do we want to assess present rates, we want to assess projected rates incorporating the anticipated regulations. We can't blindly project trends without saying that some of these trends are going to stop or change. Then let's reassess the expected demographic rates under those conditions once this habitat loss, for example, is arrested, at whatever level, and what kind of population you expect. How many individuals will you count? What will the birth rates be? What will the death rates be? Even there you might discover that the amount of habitat that is projected into the future is too little, or too fragmented. The projected future could still be a population that is predicted to decline. So it is not a foregone conclusion whether there is a future with a stable population, a slowly growing population, or a slowly declining population. You have to do those computations, and see.

If things come up positive in our deterministic demography, we come up with assessments in which we can envision a future in which we manage the world in such a way that our population has stable deterministic rates; then we have to go on to one more level. It's not a foregone conclusion the future is rosy. We have to consider stochastic demography.

That is to say, real populations live in a world that is not constant. There are good years and bad years. Sometimes there's a string of good years; sometimes there's a string of bad years. Some bad years are very bad; some good years are very good. Which means that our summarizing all of the demography in these average rates in the deterministic demography has lost a little bit of reality. And that reality might sneak up behind us and bite us. Which is to say that the population that has average zero growth, or even average positive growth, can still go extinct because of bad luck in a run of bad years. There is a whole mathematical theory, which I will not torment you with, on how we can compute probabilities of extinction. This is where these probabilities come into play.

Given assessments of two essential pieces of information, we have the kind of input we need to do stochastic demography. We need to know average rates of population growth for every population size. Which means we need to understand the density dependence of the system. And we need to know the variance in those rates at every population size. If we have that schedule, here is what the mean growth rate expected is when the population is 100 individuals; here's what it is at 101; 102; and at 1,000. There's not room in the park for more than 1,000, so let's worry about that range. You tell me the variation in the population growth rate at 100, 101, 102, 1,000. Those two pieces of information are enough to plug into the formula and give you this output, the predictions of expected survival times of these populations.

You may be getting an uncomfortable feeling that we're asking an awful lot of you. Those of you who have tried to do a census recognize that it can more than easily exhaust your resources. If you try to construct the conventional life table where you get the average rates over all the times you went out in the field, that is a challenge, and in terms of the technical mathematics, one that is very often forbidding. If you go to textbooks or to journals, at least 95 out of 100 articles dealing with demographies, life histories, life tables, that come out in the literature have serious technical errors.

And now I'm telling you that even that isn't enough. We have to go beyond the average rates and come up with estimates of what the variance of the distribution of these rates are at each density in order to make the prediction. And now, suddenly we see where we are going to have to take very seriously the question of burden of proof and standards of evidence. Without raising your expectations to unrealistic heights, let me give you my personal appraisal.

I don't think there exists a natural population for which we presently have good enough variance information, so that's obviously a very important item on our agenda. I also think it's not going to be easy to get good variance estimates. This means we cannot make it a realistic goal that we're going to spend the next 5 years or 10 years dedicated to an international decade of conservation biology exploration and make estimates of what these variances are for every species on earth. It's not going to happen.

But we can do something. So I think the government agencies owe it to themselves and to the resources to draw up a plan on a time scale of a decade for picking some representative taxa, and obtaining statistically defensible estimates of their variance rates. And at the conclusion of that time, there's going to be a gentleman's/gentlewoman's agreement that these rates that were measured will be taken to be the representative, taxon-specific default rates for that entire group of organisms. That is then the default number that gets used in the population viability analysis for an organism more or less of this taxonomic sort in an environment more or less similar. So the output of this survey, as it were, on representative organisms will not only work out methodologically for us; it should be the intention that this would provide the default values so that we'll have numbers to plug in, to make whatever decision has to be made. So that whenever one of these controversies arises, we won't have to say, "Well, we don't have the data. It would take us ten years to get it."

This default number must be supported by a consensus in order for us to use it to make a prediction.

Of course, not everyone's going to be happy with that number. There's going to be conservation groups saying that the number is way too generous. There's going to be commercial interests saying that number is way too pessimistic. But if we have this kind of administrative policy structure saying, "Right, it could be either way, we don't have the data, in the absence of data, here's the number we are going to use," it will lead to predictability and something other than chaos. And if any constituency really wants to argue, it's up to them to go out and gather the data on that population in that environment, and demonstrate using statistically accepted standards of evidence that the number is in fact significantly and detectably different from the default number.

Finally, the fourth and last step of important considerations in population viability analysis has to do with the genetic process of inbreeding. We know from a large amount of evidence with captive animals that in populations which are getting smaller there is inbreeding, and inbreeding results in a lowering of the physiological viability of the organisms, which means that the demographic rates we are using are changing. But because of the genetic process, the mean growth rates are slower than they were before, and the variance in those growth rates, the sensitivity to the environment, is greater than it was before. We are going to have to learn how to tune these predictions to take into account the effects of inbreeding. Unfortunately, the study of inbreeding has a status something like stochastic demography. We know the problem is out there, but we don't have statistically defensible estimates that will tell us generally, for example, that we have a population that was previously 2,000 individuals and now there are 1,000; here's the amount by which we need to lower the estimate of average growth rate and raise the estimate of its variance.

The data are not available, and this should trigger another agenda item for conservation biology research. We need serious systematic work on representative taxa, not necessarily in the laboratory, but drawn from populations of representative sizes to determine the appropriate coefficients to tell us that when we have the size of a population, what should we do to our estimate of the growth rate and what should we do to our estimate of the variance in the growth rate. As before, this is a statistical undertaking. We might be able to do a credible job with 20 or 30 representative taxa. That should be done. I propose that the results of the taxa surveyed should serve as the default values to decide the jump shots. So that we don't have a system that's paralyzed for lack of data.

So I think we have a fairly full menu of topics in population viability analysis which I propose as the answer to the question: How does the Park Service, owner of the island, deal with the owners of the sea regarding the need for changes in policy?

In the matter of intervention within the island we come to population viability management. We again need a mechanism for assessing probability of survival under various circumstances. Which means some of the time all we are doing is conducting a population viability analysis under different scenarios. Saying, well, let's imagine if we manage this way. We must find a combination of management options that yields an acceptable persistence value for a population.

A second version of population viability management will be different from simply doing population viability analysis. This second version should answer the question of specifically "when" to intervene. We could have a population where we predict that the mean time to extinction is, say, 2,000 years. Let's also say two thousand years is over the accepted threshold. That still doesn't mean that we should adopt a hands-off policy for that population because that prediction was an average outcome using stochastic demography. That population varies from one year to the next; population size going up, population size going down, droughts, floods, predators, diseases. Maybe during the course of that wandering, we should intervene and not let stochastic demography play out its course. Maybe there are times when we should in fact contemplate inoculating the animals against diseases, controlling predators, controlling competitors, supplying additional resources, etc. Much of this is repugnant to a wilderness image of what we'd like the parks to be. But maybe some of this is part of a dream world, if the parks as islands are so small that we have to intervene in order to achieve acceptable longevity for certain populations.

So what is going to be our criterion for action? What is going to be the kind of number we use to trigger the decision that now is the time to go to work and do something about the population?

Let me propose just one example. Let's consider a possible criterion, the probability of recovery. What do we conclude if we have a population that is fluctuating under stochastic demography in a range between one individual and k individuals, and right at the moment it's at ten individuals, somewhere between? What is the probability that a population, now size n, will recover back to its ceiling, size k, before extinction? Which means, what is the probability it will recover to a status which is as good as we can expect? Let's consider calling that the probability of recovery and using that number as a percentage as our trigger for when to intervene. Let's imagine that we accept 99% as the threshold. Now, we're not going to accept this just because I said so; this number would be arrived at through consensus. Then for a particular population size, there is a mathematical procedure analogous to the population viability analysis using exactly the same quantities with a different formula. It will tell us the probability of recovery for a population in these circumstances given that the size is n. If we find that the probability of recovery is 99% or above, we say fine, we shouldn't intervene. That's our policy. If the probability of recovery is lower than 99% recovery, we say, we'd better do something. And as to what we should do, that then becomes a matter of conventional population demography.

What are the things we can do to enhance the growth rate of the population at least temporarily, and in a sufficient fashion to get population size back up to an acceptable range? Since we're talking about the same information needs as a population viability analysis, this will be on the same five-year or ten-year survey agenda of numbers that have to be measured in a representative and systematic way, and the consensus that has to be achieved as to the default numbers that will be used when data aren't available for that particular species in that particular place.

Keynote Address: Management

Boyd Evison
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Thirty-five years ago, in *Round River*, Aldo Leopold wrote:

> The outstanding scientific discovery of the twentieth century is not television, or radio, but rather the complexity of the land organism. Only those who know the *most* about it can appreciate how *little* we know about it. The last word in ignorance is the who says of an animal or plant: "What good is it?" If the land mechanism as a *whole* is good, then every part is good. If the biota, in the course of aeons, has built something we like but do not understand, then who but a fool would discard seemingly useless parts? To keep every cog and wheel is the first precaution of intelligent tinkering.

He added that "not even the scientist" recognizes all of the "parts of the land mechanism."

We're here today because--tinkerers all--we have begun to really understand that message--but at different rates, and with various twists of perspective. A big part of our job, it seems, is to get in sync, to recognize our shortcomings and strengths, and to develop a new, systemwide symbiosis between scientists and managers--and above all, to stop accepting ignorance.

But we can't do this by getting at cross-purposes with ourselves or our legal mandates. If any of us ignores the basic mandate of the National Park Service, or fails to recognize the makeup of the deck that we've been dealt from, we'll waste a lot of time and money, and get nowhere.

The National Park Service is made up of people pretty strongly committed to meeting the basic mandate given us in the Act of August 25, 1916, which said that we are to *promote* and *regulate use* of the parks, managing them for this basic purpose:

> . . . to *conserve* the scenery and the natural and historical objects and the wild life therein, and to provide for the enjoyment of the same in such manner and by such means as will leave the *unimpaired* for the enjoyment of future generations.

And we will do our best to prevent anything from undermining that mandate, as we understand it.

Does that mandate pose any problems for the preservation of biological diversity? Well, it might. "Promote use," and "provide for enjoyment," it says. With use comes, at least, the *possibility* of loss of plants and animals or of their habitat--the loss of individuals, for sure; of populations or communities, maybe.

But enough of them to endanger the last of any of them? Not if we do our job right. And we do take the "conserve . . . unimpaired" part of our mandate seriously, even if we have served it imperfectly at times.

One cannot *use* and *enjoy* what one has wiped out--or what has been forced to become something else. Nor can one *study* what has not been protected from alteration by way of overzealous study.

The Service has been given some additional statutory responsibilities. The legislation that created certain parks gives special protection to selected features, species, or scenes. Other laws have given us, Servicewide, a share of the responsibility for cultural resources, wilderness, endangered species, clean air and water; and specific responsibility for protecting against "derogation of the values and purposes for which these various areas have been established," in places declared to be "united through their interrelated purposes and resources into one national park system as cumulative expression of a single national heritage."

No problem for biodiversity in that, is there? But hold on--we have also been required, in some places, to permit recreational hunting; consumption of plants and animals for subsistence; off-road travel by snowmobiles and motorboats; landings by airplanes; removal of fish by hook and line; and construction of roads and utility lines. Even in wilderness. For some of these, we have been given little or no choice. In most, we have the opportunity to exercise some control over the locations, times, and extent of such uses or installations. So, in these, there can be measures to avoid irretrievable losses--*where we recognize the likelihood of loss.* In some, what choices we have may only be between routes, times, or places of destruction.

Some parks' enabling legislation explicitly calls for the protection of ecosystem integrity. The Alaska National Interest Lands Conservation Act (ANILCA)--which in Alaska parks permits many of the nonconforming uses I've just mentioned--tells us to "maintain . . . natural environmental integrity" and to "assure continuation of geological and biological processes unimpaired . . ." in various Alaska units. So it put into explicit language what we have come to infer from the 1916 Act for *all* of our natural areas.

That inference arises from the reasonable assumption that we can't "conserve . . . wild life . . . unimpaired" unless the ecosystems of which wildlife are an integral part are kept unimpaired.

Is there anything at cross-purposes with that, in the pursuit of preservation of biological diversity? Well, *maybe* not. Certainly not, if the entire range of each component of every park's biota were included within park boundaries. But try that on migratory birds or butterflies--or on such long-haul critters as whales, or salmon, or caribou, or even wolves. Given the size of most of our units, try it on even *less* impressively mobile species!

What happens if we find that a genetically unique population can survive in a park *only* if we compensate for perturbation occurring in other parts of its range, by counter-perturbation *within* the park? Counter-perturbation can be counter to ecosystem integrity. But so is the loss of one of the ecosystem's components. So, we manipulate to protect such components--*within reason.*

And "reason" *could* rule out such manipulation. For example, we wouldn't flood Cades Cove to provide for the survival of an endangered top-minnow. I hope. Many choices aren't that simple, of course.

We must be certain, before disrupting park ecosystems for the benefit of some threatened species, that there isn't an alternative at least as promising. If protection of the winter range of some threatened ungulate can be provided, even though not within park boundaries, by a firm arrangement with other land managers, that's preferable to, say, mowing to maintain winter range *inside* the park. And that's why probably every natural area that we manage should be managed as if it were a part of an International Biosphere Reserve.

But, if forced to choose between permanently altering a unique ecosystem--and what one is *not* unique, by the way?--inside a park, or the likelihood of the loss of a threatened or rare species, which is a manager to choose? The answer to that probably is in the Endangered Species Act. But how sure are we that we are not endangering another, as-yet-unrecognized species or process, by what we do? We'd better have the courage to say, "Wait. Let's take a hard look at this--with all the expert advice we can get."

A major reason that it's important to have scientists on park staffs, or close at hand, is their ability to recognize those occasions when some action--or inaction--seemingly compelled by common sense, but based on insufficient knowledge, may make matters worse. Scientists willing to speak up, and close enough to reflect understanding of managers' daily dilemmas, in doing so.

Which brings us to another essential consideration in our search for symbiosis--the human beings responsible for management of the parks, and the subculture in which they exist.

One good source of insight into us is in what John Dennis and others have outlined as the evolution of our interpretation, in policy, of that basic legislative mandate. Our first response, decades ago, was simply to prevent poaching (an acute problem again today); then, to control the "bad" things, like predators and fire; third, to recognize that those bad things are not necessarily bad after all; fourth, to see the link between intensity of use and the necessity for compensatory management; fifth, to see the necessity to mitigate the impacts, on parks, of human activities *outside* of parks; and finally, to see the need to manage parks as parts of larger ecological units--the Yellowstone/grizzly ecosystem, or perhaps the Western Arctic caribou/grizzly/wolf ecosystem.

That evolution actually has spanned more than 100 years. It has not been a steady, smooth process. While George Wright moved us toward responsible management in the 30s, we or our partners went on feeding black bears as attractions--and killing them when they "got out of hand." And in the 80s (until '86), while some managers and scientists cried for support for baseline data building, and studies of the *effects* of air pollution, most of our money went into Servicewide studies of *visibility*--"sexier," we were told.

Still, some of us managed to scrape up the means of getting started, in spite of organizational counterpressures. Point: we're not the monolithic, single-minded outfit that some would have you believe we are. And a good thing we aren't. A little dissension, and "countercultural effort," can be better than marching in lock-step to whatever is "sexy"--whether it's visibility--or blind pursuit of biological diversity!

What seems to have been sexiest lately is the notion that things are worse *inside* the parks than they are outside. There *are* some real problems out there; and some of what is making media figures of glib scientists *needs* attention from us.

Newmark may be correct in suggesting that we have let animal populations disappear from our parks. Where we could have prevented this, we should have; and one reason for our being here this week is the recognition that we should not let it go on happening--should, in fact, reverse it where we can. Of course, in many places, including Great Smoky Mountains National Park, we have been painstakingly engaged in doing just that. But the more interesting revelation of Newmark's work may be between the lines. It's entirely possible--in fact, quite likely--that some of the species not recently recorded in park files are still in those parks! It may even be that some, recorded or having been observed in bygone years, never were there! The *real* problem is that we seldom really took stock, carefully and systematically. But the fact remains that these little islands we manage have been degraded by the loss of some of their natural living components and we should have done more to prevent it.

Now there are reasons for hope--and much to do--if we are to avoid seeing those hopeful signs become ends in themselves.

In recent years, research and resources management--of both natural and cultural resources--has received much more attention from the National Park Service. The natural resource management training program has continued to produce people--and positions-- bringing new levels of awareness to park management. Earlier efforts at raising the level of managers' understanding of complex resource problems have been substantially augmented.

Mott's arrival generated the 12-Point Plan, which is naturally a target of the usual cynicism, but which very definitely triggered some very good things that some of us frustrated souls had been unable to get much support for in the past. I've been a Regional Director for less than three years. As recently as the summer of 1986, an attempt by some of us to make an in-depth look at the Service's natural resource research and management policies, programs and projects, the subject of one of our quarterly meetings, met with considerable lack of enthusiasm or understanding. A pretty superficial treatment slipped by us unscathed by much in the way of hard questions. But the 12-Point Plan's edict for inventory and monitoring, and for Servicewide assessment of resource management needs, led to steps that have dramatically affected the entire Directorate. The result, through obligatory steps laid out by specific action programs--augmented by increasing Congressional recognition of the System's needs-- was evident in the meeting of the Directorate in January of this year. The Service's programs and policy leaders are now giving the direction they--we--are responsible for.

That change in awareness, and in commitment, constitutes a quantum jump. But it is only the first of several jumps that are needed; and the landing was a little shaky. That shakiness, and our willingness and ability to pull ourselves together, to be sure our next leap--or step--lands us where we *should* be, has something to do with how we perform as stewards of biological diversity.

What do I mean by shaky? Well, our ability to proceed wisely is disrupted by several things. For starters, our grope toward development of a good inventory and monitoring system has been a bit slow and halting--forgivable, perhaps, in light of the years of catch-as-catch-can and the remarkable absence of great examples, but frustrating nevertheless; and there is reason to believe our Servicewide assessment of resource management needs is warped by inadequate standards of measurement (for which I accept a major share of the blame) and/or by wide differences in their application, from region to region. It is, nevertheless, the best assessment of needs we've ever done, and the result should be enough to awaken us forever to how dangerously we have underrecognized and underattended the needs for research and resource management. Some regions identified huge needs. Others identified less, for various reasons. Often, their problem was the lack of much more than the most rudimentary knowledge of current resource conditions and trends. The needs are far greater than the 100's of millions of dollars' worth that we've noted.

What worries me most is that we seem confused and misled by the infusion of money from fees, and are still struggling to figure out how to compensate for our inability, under existing law, to direct that money where it is most needed.

Bill Mott, in our House appropriations hearings in March, said he needed discretionary use of more than the 10% of fee revenues for which discretion is provided, for 1989, by law. The other 90% of it is distributed, by rigid statutory formula, mostly to parks with big gate receipts and big budgets--not necessarily those with the most pressing needs.

He's absolutely right. He does need greater discretion to counter that maldistribution; and some of us already have gone rather dangerously far in calling this to the Congress's attention. But, responding to Chairman Yates's zeroing-in on maintenance related safety problems, Bill pled for freedom to apply fee revenues to maintenance. Maintenance of all kinds.

And believe me, we have all kinds of maintenance needs. To meet them properly, we need, eventually, *billions.* Fee revenues, which the Congress fortunately has focused on meeting the needs for increased research, resource management and protection, and interpretation, would not go far if diverted to maintenance. But neither should we have to accept, as a new standard for NPS maintenance, just enough to keep from killing or maiming visitors and employees! Additional funding is desperately needed for it. I hope we aren't really forced to choose between something that barely prevents collapse, and finally taking real steps to avert resource calamity.

Meanwhile, if Servicewide sources of natural resource funding, and their cultural resource counterparts are reduced as proposed, parks desperately in need of baseline information will, inevitably, be defenseless if, for example, such things as the panic-driven industrialization of Alaska proceed to empty poisons into park airsheds.

We may be about to let many parks' crucial needs go unattended, by the faulty assumption that those fee revenues are somehow properly compensating for the cuts we may take in Servicewide programs for research and the care of natural and cultural resources.

It's interesting to see how often we are deceived or betrayed--or both--by our lack of baseline data. Reliable, thorough inventories and periodic reassessments *must* become ingrained in the Service's way of "doing business" at the park level. And that kind of stuff, of course, is not very sexy to a lot of scientists. So the work isn't self-generated. (We don't get it "free.")

Let's be *very* careful about tinkering with ecosystem integrity--even on behalf of genetic diversity--until we really know what we have, and what's happening to it. We need to hitch the "string" of biological diversity to an inventory and monitoring "puller," not a good-intentions "pusher."

And finally, let's work together to reach the American--and world--public(s) with the *reasons why we must do these things*. Not just those good scientific reasons, but also the emotion-laden context in which they exist. When Aldo Leopold wrote:

> A thing is right when it tends to preserve the integrity, stability, and beauty of the biotic community. It is wrong when it tends to do otherwise.

he wasn't rationalizing. He was putting into words, what is there in the core of each human being, woven through all of us by a ribbon of common genetic bits: The *need* for *diversity*. Diversity in shapes, colors, intensities, textures, tastes, aromas, sounds, motions, sequences, and combinations of them--observed, personally experienced, or simply known to *be there*--and generated by diverse living and inanimate entities, interacting freely. In our communications on behalf of ecosystem integrity, for a healthy world ecosystem, for biological diversity, we need to raise awareness, at the gut level, that each loss *diminishes forever the richness of the world's possibilities.*

My message, then, isn't all that startling or innovative. But it's one that is easily overlooked. And when it's overlooked, we are bound to stumble.

It can be seized in terms of Aldo Leopold's tinkerer analogy.

- We're all pretty well aware that "To keep every wheel and cog is the first precaution of intelligent tinkering."

- We still haven't quite brought ourselves to making sure just what cogs and wheels we have, and what shape they're in. And one result is some seriously flawed conclusions about the condition of the machines.

- We need to keep in mind the *kind* of machine those cogs and wheels are parts of, and what it is supposed to *produce*. In our case, that machine is supposed to be, and produce, ecosystem integrity, or as close to it as possible.

- If one of those parts has been worn down badly by a neighboring piece of machinery, or if it's been lost, it doesn't necessarily make sense to force a nice, new replacement part into the machine's innards, just to be sure we'll always have one. If we do, the machine may never be quite the same again. It may even chew up that same part, again--and maybe some others with it--in the long run.

- We'd better put our heads--and voices--together, and make sure no one starts tinkering until we *have* checked out those parts--developed good baseline data on park biota, and how they function. Even when the tinkering is for a very worthwhile cause.

- Further, we'd better do everything we can to make sure that periodic checkups--of the whole machine, by way of regular readings on its key parts, at least--is as built-into the National Park Service base budget, and our basic, unswerving way of operating, as our system of government will permit it to be.

- With that information in hand, and assuredly forthcoming into the future, we must become the world's best symbiotic management/research organism, providing a major share of the means of preserving biological diversity, in a cooperative venture involving much more than the NPS and its pieces of the mosaic.

- It won't be easy.

- It must register indelibly on the *emotions* of our many publics, whose support is essential to the kind of commitment--immediate and long-term--that is essential to its success.

- We will make mistakes (as we have in the past).

- It can be done.

So let's have at it.

SECTION I

Management Policies and Issues

Peregrine falcon
(Falco peregrinus)

Section I. Management Policies and Issues

Participants: Robert Baker, Susan Bratton, Boyd Evison, Warren Hill, Cliff Martinka, Dave Mihalic, Nora Mitchell, Dennis Murphy, Harold Smith.

The Problem

Despite an implicit NPS mandate to conserve biological diversity in national parks, species losses and ecosystem degradations continue to occur. Fundamental changes are needed in the management of our national parks to conserve adequately the full array of native ecosystems, communities, species, populations, and genetic resources, as well as the natural processes that influence them. Current management policies focus on the preservation of large vertebrates or rare and endangered species and avoid other key taxonomic groups such as small vertebrates, insects and other invertebrates, non-vascular plants, and microbes.

Recommendations

1. *The National Park Service needs legislation providing explicit statutory responsibility to protect biological diversity.* An act such as that protecting biological diversity on USDA Forest Service lands would specifically direct NPS managers to protect biotic resources.

2. *The National Park Service needs to integrate this explicit biological diversity mandate with existing environmental protection laws and policies.* The NPS is already responding to a variety of environmental laws, including the Endangered Species Act and the National Environmental Protection Act. Much of this existing legislation directly or indirectly affects management of native species or ecosystems and thus needs to be interpreted so park managers can understand its relationship to the protection of biological diversity.

3. *The existing inventory and monitoring policies of the National Park Service need to be implemented fully.* The NPS already has or is

developing standards for inventory and monitoring of biological resources and should currently be determining the amount and type of biological diversity located in the parks. Not all parks have inventory and monitoring programs, however, and the quality of the information gathered varies widely from area to area (see also II, III, V). NPS management should give further funding and guidance to existing programs.

4. *The National Park Service needs a mandate for the restoration of extirpated or degraded ecosystems, or their components.* Park managers rarely attempt reintroductions of extirpated species and may not attempt to recover ecosystem elements recently lost. A stronger policy would encourage more restoration and recovery efforts. (See also IV, V.)

5. *The National Park Service needs a series of procedures for measuring, and criteria for evaluating, biodiversity.* At present, most evaluations are on a park-by-park basis. With the wide variety of species and ecosystems protected by the national parks, a completely standardized system of determining biological diversity within and between areas is probably not practical, but guidance in appropriate methods would be very valuable for park managers and would help accelerate information-gathering efforts.

6. *The National Park Service needs a strategy of cooperation with landowners and management agencies external to the parks, on local, regional, and global scales.* (See also all other sections.) For example, cooperation is imperative between the NPS and the U.S. Fish and Wildlife Service, which has responsibility for the recovery of endangered species inside or outside the parks. The NPS, in turn, may be able to set an example for other nations trying to preserve biological diversity, and may be able to offer international leadership in the field. Some cooperative programs, such as the Biosphere Reserves, should be further expanded to aid in the conservation of biological diversity. (See also V, VI.)

7. Since present park management policies emphasize non interference in natural processes and disturbance events, *decision criteria are needed to determine when intervention in natural processes is justified to conserve biological diversity.* This is particularly important when a biotic resource is at risk outside a park. Examples of problems requiring better policy definition include: (1) the maintenance of rare species populations by anthropogenic disturbance, (2) treatment of

endemic diseases to prevent native species population collapse, (3) suppression of natural fire to prevent loss of a nesting area or other rare species habitat, and (4) maintenance of anthropogenic habitats to retain high numbers of a species presently extinct outside a park. Parks also need to know when they should bring genetic material in from outside the park to reinforce a population present in small numbers in the park, and what sorts of human manipulations are acceptable in reintroduction and species recovery efforts.

8. As the steward of many historic landscapes and cultural areas, *the National Park Service needs clear standards to determine when biological diversity should be conserved in seminatural ecosystems (e.g., historic hayfields or wet meadows) or in parks focusing on cultural resources.* For example, the Park Service protects rare or historic cultivars, minor animal breeds, and unique agricultural communities, such as historic orchards. These primarily cultural resources may contain genetic materials of scientific interest, or may provide habitat for native rare species. Managers of historic and cultural sites need policies appropriate to their areas and resources.

9. *The National Park Service needs to build accountability for the maintenance of biological diversity into the management and administrative systems of the NPS.* At present, if biological diversity is lost from a park, no one is held managerially responsible. This lack of accountability is rooted in the lack of direct legislative mandates and policy statements concerning biological diversity. Few superintendents or regional directors have any professional goals concerning biological diversity in performance standards, yet until management feels compelled to protect biological diversity, other sorts of initiatives will take precedence.

10. As a lead agency in protecting biological diversity nation- and world-wide, *the National Park Service needs to communicate effectively to the public the importance of preserving biodiversity.* This action is important not only to maintain public advocacy for sound resource management in the parks, but to help establish a national-level response to the underlying causes of the worldwide crisis in biodiversity. (See also all other sections.)

SECTION II

Inventory and Monitoring

Brook trout
(Salvelinus fontinalis)

Section II. Inventory and Monitoring

Participants: Peter Brussard, Neal Guse, Frances Kennedy, John Ogden, Mike Soukup, John Varley, Jared Verner.

The Problem

Before biological diversity can be adequately protected, the NPS must know what is present on Park Service lands. Yet existing data bases are inadequate; most reflect an opportunistic rather than methodological approach, and they seldom are fine-tuned enough to be able to monitor changes in park biodiversity. Protocols from park to park, or from Park Service to and from other agencies, are not standardized, making comparisons among units and over time difficult if not impossible. There is no agreed-upon minimum state of knowledge either for the NPS or for individual parks. It is clear that there must be both a standardized servicewide component and an individual park component to any inventory/monitoring system.

Some data bases relating to biological diversity already exist. For example, some parks (e.g., Channel Islands, Yellowstone, Great Smoky Mountains, Sequoia-Kings Canyon) have certain components of an inventory and monitoring system already in place. Likewise, state Heritage Programs initiated by The Nature Conservancy often contain useful information for the NPS, and the National Science Foundation (NSF)-funded Long-term Ecological Research (LTER) projects, although not designed to address biological diversity per se, often monitor some of its components. However, these data bases by themselves are inadequate for the NPS's needs.

Recommendations

1. *NPS policy should be rewritten to reflect special concern for biological diversity.* Perhaps the enabling legislation for Channel Islands

National Park and the U.S. House of Representatives legislation in progress (HR 4335, the Scheuer Bill) could be used as models for servicewide legislation to ensure the success of a long-term program.

2. *The NPS should begin an adequately funded, sustained servicewide inventory and monitoring program, to be integrated into the operations of all appropriate park units.* Protocols for this program must be sufficiently standardized to allow comparisons among units over time. Monitoring must be conducted on an ongoing basis and must transcend the tenure of individual superintendents or variable funding themes and priorities. Thus, monitoring needs to be a line-item subset of the resource management budget; in the interim, parks might be encouraged to use fee-enhancement funds for this purpose. (See also I, III, V.)

3. *The protocols for the inventory and monitoring of biodiversity should address the following concerns, for both servicewide and individual park programs:*

a. *Coordination/collaboration with other agencies* (such as the USDA Forest Service, the Bureau of Land Management, and the U.S. Fish and Wildlife Service, as well as non-governmental organizations such as The Nature Conservancy) should be mandatory. This is particularly important for understanding events that occur outside park boundaries that can affect biological diversity over time. (See also I, V, VI.)

b. *Statistically sound sampling plans* must be developed. For example, the park-wide protocols must choose between using frequency or abundance data, and must designate the number of sampling sites, the sampling design (random, stratified-random, non-random), and sampling frequency.

c. *Appropriate taxa* for inventory and monitoring must be chosen. At a minimum, these should include vascular plants, most vertebrates, selected invertebrates, and the diversity of habitats they require. Information should also be included on the genetic diversity contained within a broad sampling of selected populations of benchmark, rare, threatened, and indicator species. (See also III.)

d. *Appropriate elements of the abiotic environment* (e.g., soils, water, atmosphere) must be selected, inventoried, and monitored. (See also V.)

e. *Available technology* (e.g., Geographic Information Systems (GIS), remote sensing) to be used within and outside of the system must be assessed and designated, with direct and easy access to the data. *New technologies* for the reconstruction of past environments (e.g., dendrochronology, atomic dating techniques, pollen analysis) must be incorporated into the protocols.

f. *The potential of future technological developments* (e.g., third-generation satellite imagery, portable location transponders, advances in molecular genetics) must be evaluated, and the NPS should be actively involved in their design and application. Techniques to incorporate past data bases into a retrievable, user-friendly, GIS-based format must be selected.

g. *Standardized techniques for database management* (e.g., accurate location of sampling sites in field; retrievable, GIS-based formats) must be developed. These should include methods for the production of hard-copy maps and other information and guidelines for designating other institutions (e.g., nearby museums or universities) for achival storage of duplicates for these materials.

h. *To ensure rigorous quality assurance, standards must be set for the peer-review of these protocols* and their subsequent application. Periodic data review, synthesis, analysis, and discussion are necessary to make the program meaningful to the park employees who interpret the data to visitors.

i. *Methods for involving outside expertise* (e.g., scientists from universities and other agencies), *alternative funding sources* (e.g., NSF participation in developing and implementing these programs), and *citizen volunteers* in data collection and analysis must be developed.

SECTION III

Viable Populations

Flame azalea
(Rhododendron calendulaceum)

Section III. Viable Populations

Participants: Paul Buckley, William Ehorn, Mike Gilpin, Jim Hamrick, Christine Schonewald-Cox, Mark Shaffer, Ted Simons.

The Problem

To ensure the long-term health of natural ecosystems and the biological diversity of the National Park System, it will be necessary to maintain viable populations of native plant and animal species within individual parks. But the chances for a population or species to survive in any area depends on the amount, quality, and spatial distribution of available habitat, as well as the size of the population and the kinds and degrees of demographic, environmental, and genetic pressures to which it is subject. These considerations may demand much larger population sizes than are currently contemplated in park management plans if those species are to exist as viable, self-sustaining populations. The development, testing, and application of new methods of population viability analysis (PVA) are needed to guide planning and management, both to protect present resources and to prevent future population declines or extinctions.

The problem of maintaining viable populations in the National Park System is composed of four major elements:

1. We need to know the critical factors in the ecology of a species that may contribute to a reduction in its viability (e.g., habitat loss, exotics, disease, etc.). This may demand additional habitat acquisition and new management techniques.

2. We need early warning to forestall problems in those species that currently appear stable and may not yet be experiencing systematic declines in their populations or in the quality of their habitat. Changes in the ecology of species (e.g., habitat fragmentation, reproductive failure, increases in mortality, etc.) that might affect its long-term viability should be documented *prior to reaching a crisis situation.* This will require a well structured monitoring program.

3. We need to better understand how these factors (population size, habitat availability, and demographic, environmental, and genetic variability) relate to one another over the long term. This points to a need for long-term population studies.

4. We need to be able to determine accurately the population size, habitat size, and distributional requirements necessary to prevent population or species extinction. Such information will, in many cases, determine the ability to develop effective management programs.

Theoretical models for assessing the impacts of various extinction factors on population growth, decline, and persistence are developing rapidly. For example, it is well known that population persistence is not only a function of population size, but is influenced by variations due to demographic, environmental, and catastrophic events. Population genetic theory is also rapidly developing regarding the effects of population size, natural selection, gene flow, and inbreeding on the maintenance of genetic diversity within and among natural populations.

Further theoretical development is a continuing need, but the greatest need at this time is for reliable estimates of relevant measures of wild populations for use in PVAs, such as those discussed above and below. Without empirical data to test and modify existing theoretical models, use of population viability analyses will remain largely theoretical and will be of limited value.

Recommendations

1. *All national parks with natural area management zones should have a basic inventory of their indigenous plant and animal species and the communities they form.* Such data should include life history, spatial distribution (within the NPS unit and elsewhere, such as on other public lands in the surrounding region), and abundance information. (See also II, V, VI.)

2. *PVA candidate species should be identified* from appropriate considerations, such as the Endangered Species Act. These should include species that, although not endangered, may be crucial to the survival of other species or the ecological character of indigenous communities *(keystone species)* or those species that are generally representative of

other species *(benchmark species).* Care should be taken to select candidate species which can serve as models for a guild of species with similar life histories (e.g., herbaceous plants, canopy trees, insectivorous birds, top predators, etc.). (See also II.)

3. *Population viability analyses should then be conducted for a representative set of species whose long–term viability is at risk.* For each chosen species, research should determine:

a. *Basic demographic parameters and their variability,* measured over a long period of time in order to document temporal variations in mortality, reproduction, etc.

b. *Levels and distribution of genetic variability.* Enzyme, morphometric, and physiological characteristics should be measured because available data indicate that patterns of variation in one suite of traits may not be indicative of variation in other suites of traits.

c. *Community and anthropogenic relationships and effects.*

d. *Spatial distribution and dispersal behavior.*

e. *Natural disturbance regimes and their effects.*

From this information, detailed PVAs can be developed to help guide long–term resource planning and management. (NOTE: Wherever appropriate and useful, experiments should be conducted to test extinction models and the validity of extrapolating from benchmark species to other species. This will require conducting some additional, perhaps less intensive, studies of selected species to measure how well benchmark species represent other species.)

4. *Wherever appropriate data exist, PVAs should be used now to better inform management decisions.* Such uses might include the EIS process, feasibility assessments of proposed reintroductions, or assessing the effects on viability of such interventions as culling, supplemental feeding, predator control, habitat manipulation and genetic manipulation, among others. To make informed decisions concerning these factors, detailed information on species biology is critical.

5. *NPS, in conjunction with other major land and wildlife management agencies, should undertake and support a system of*

techniques and procedures for planning and management applications. (See also I, II, V, VI.)

6. *Viability models for these applications should be refined and integrated to stress generality* and to minimize both the demand for extensive or detailed data and the level of theoretical and quantitative background required of users for effective application. Nevertheless, any model should incorporate means for explicitly stating the level of certainty in both the input data and the model's inherent relationships.

7. *The relationship between environmental and demographic variability should be investigated,* both for those species for which adequate data exist and for other benchmark species. It is critical to assess any cause/effect relationship between the ecological health of a population/species and those environmental factors that affect mortality, recruitment, etc.

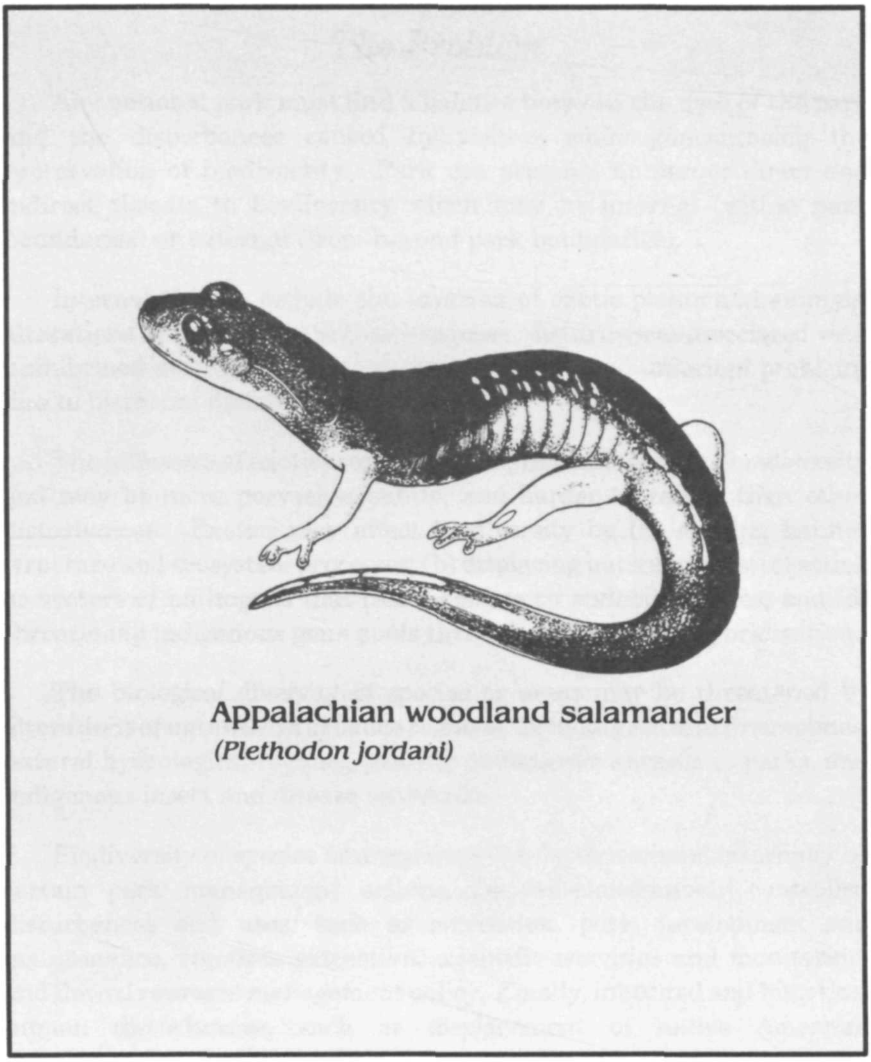
8. *Long–term (minimum 10–20 years) ecological studies should be established* in conjunction with other ecosystem research programs (e.g., LTERs, Biosphere Reserves, Forest Service Experimental Forests, etc.) to collect the demographic, genetic, environmental, and ecological data necessary for the understanding of long–term population viability and its management. Many critical demographic and genetic factors occur only rarely and randomly, but they may play a critical role in the long–term viability and evolution of a population or species. (See also V.)

9. *The synthesis and interpretation of long–term studies* and the testing of selected species' population projections should be promoted through centralized data bases, workshops, joint projects and networks to facilitate communication among theorists, field scientists, and managers. (See also V.)

10. *The National Park Service should take a leadership role in educating and translating to the public* and to other land management agencies the importance of maintaining biological diversity, the challenge of doing so for many species, and the knowledge and coordination of various agency programs necessary for success. (See also I, II, IV, VI.)

SECTION IV

Human Disturbance



Appalachian woodland salamander
(Plethodon jordani)

Section IV. Human Disturbance

Participants: Richard Cunningham, Andy Dobson, Dale Enquist, Nik Lopoukhine, Gary McCracken, Jeff Marion, L.K. Thomas, Jr., Bruce Wilcox.

The Problem

Any national park must find a balance between the uses of the park and the disturbances caused by visitors while guaranteeing the preservation of biodiversity. Park use presents numerous direct and indirect threats to biodiversity which may be internal (within park boundaries) or external (from beyond park boundaries).

Internal threats include the invasion of exotic plants and animals, alterations of natural disturbance regimes, disturbances associated with uninformed management policies and practices, and inherited problems due to historical disturbances.

The influence of exotics represents a significant threat to biodiversity and may be more pervasive, subtle, and harder to rectify than other disturbances. Exotics may affect biodiversity by (a) altering habitat structure and ecosystem processes; (b) displacing native species; (c) acting as vectors of pathogens that cause disease to endemic species; and (d) threatening indigenous gene pools through introgressive hybridization.

The biological diversity of species or areas may be threatened by alterations of natural disturbance regimes, including natural fire regimes, natural hydrological regimes, grazing of domestic animals in parks, and indigenous insect and disease outbreaks.

Biodiversity of species or areas may also be threatened internally by certain park management actions, i.e., administratively controlled disturbances and uses, such as recreation, park development and maintenance, resource extraction, scientific activities and monitoring, and flawed resource management policy. Finally, inherited and historical human disturbances, such as displacement of native American populations, may pose an additional internal influence on biodiversity.

Human-induced changes associated with activities outside park boundaries have a significant impact on the biological diversity within parks. (See also V, VI.) Activities occurring throughout the world, such as the burning of fossil fuels, are leading to global changes in climate and atmospheric pollution. Other activities occurring regionally beyond park boundaries, such as development, deforestation, agriculture, and the release of environmental toxins, are leading to reductions of migratory bird populations worldwide. Activities occurring in lands adjacent to park boundaries and within inholdings, such as agricultural development, urbanization, and industrialization, are leading to the loss and alteration of habitats, pollution of air and watersheds, and increasing insularization of the national parks. The introduction and release of exotic species outside park boundaries provide the source for their introduction onto park lands with the impacts described above.

Recommendations

1. An idealized goal would be to eliminate all exotic species from national parks. However, some exotics may pose little or no threat to biodiversity. *A more pragmatic strategy is to focus on reducing the densities of harmful or detrimental exotics to a level where their influence is minimized and possibly eliminated.* Long-term monitoring of such manipulated communities should increase the understanding of community structure, and should help prevent reinvasions. More research is needed to learn how to control exotic species using techniques appropriate to wild lands.

2. While it may be impossible to recreate historical fire regimes, *instituting a prescribed burning program based on the best available scientific evidence may tend to maintain or enhance biological diversity.* Alteration of historic fire regimes primarily results in unnatural habitats and a reduction in biodiversity. This alters the proportion of the habitat in different seral stages, and increases the potential for catastrophic changes that may be beyond a species' ability to adapt.

3. Further, *research on the relationship of fire regimes to diversity is needed for different types of biological communities.* This should be supplemented with research to determine the natural rate of fire incidence (e.g., pollen analysis or tree-ring data). Management might

also consider alternatives to fire as a means of maintaining diversity, particularly where fire was not a significant element of the indigenous system.

4. *Research should concentrate on determining historical patterns of water regimes.* Disturbances to the water supply are likely to have different effects on biological diversity in different habitats, or when surface or subsurface waters are manipulated. For example, altering the frequency and intensity of water flow will in general lead to a loss of biological diversity; this may also be true of altering the water table or changing drainage patterns by damming or channelization.

Interdisciplinary interactions among sedimentologists, hydrologists, and ecologists should prove useful, as would reconstructions of historical patterns from stratigraphic analyses. Present rates of water movement should be monitored, and the response of different soil and vegetation types to hydrological disturbances should be investigated experimentally.

Water resource management plans do exist for some parks. They need to be reviewed and modified where necessary to consider biological diversity. Parks with water concerns should consider biodiversity when developing a water management plan.

5. The influence of grazing by domestic (exotic) animals is detrimental to biodiversity. *Such grazing should be eliminated,* except in those cases where it is needed to maintain an ecologically disturbed zone or highlight some particular feature of historic significance. *Research should continue on the interaction between herbivores and plants,* and the existing body of literature on this topic might be collated into a management document. Existing theory and data could be used to direct new research and long-term monitoring of natural plant-herbivore relations. This would be invaluable in increasing our ability to manage indigenous plant-herbivore systems in different parks.

6. Indigenous insect and disease outbreaks were undoubtedly important in determining historical levels of biodiversity. *More attention to their possible role should be considered when determining management policy.* Human interference, in the form of control, may not always be advisable, though political pressure from private concerns or neighboring organizations (e.g., U.S. Forest Service) may have to be considered when determining policy. Synthesis of existing literature and

a program of long-term monitoring and experimental studies would be useful as well.

7. Recreational users have direct and indirect impacts on biological diversity. For example, visitors may directly trample rare plant communities, or indirectly displace animal populations by hiking or camping in their primary or essential habitats. Parks have the capacity to control and even capitalize on recreational use. *This should begin with the education of park personnel, but ultimately emphasis should be placed on educating the public on the meaning and importance of biodiversity.* (See also I, II, III, V, VI.) It may even be possible for members of the public to be trained to aid in monitoring and protecting biodiversity. This may in turn lead to increased commitment to conservation on both local and national scales.

8. Regulation of park development and maintenance activities needs to be more sensitive to their direct and indirect impacts on biodiversity. For example, concentration rather than dispersal of visitor facilities, such as camp sites, parking lots, and administrative buildings, may localize and restrict the damage caused by run-off from these facilities. *Basic resource inventories and ecological assessments must precede development and must be made an integral part of the NPS planning process* to eliminate or minimize impacts on natural components of biological diversity. (See also II, III.) Development and management plans need to be reviewed by ecologists to ensure that impacts on biological diversity are adequately assessed and considered in management decision-making.

9. Activities such as recreational fishing and collection and poaching of plants and animals (especially those that are rare or threatened) have a direct adverse effect on biological diversity at the species level. These activities also have indirect effects on other populations in the community by altering or displacing the "natural" ecological functions of indigenous systems. *The commercial extraction of petroleum, mineral resources, and water, as well as the harvest of terrestrial and aquatic species, reduces a park's biodiversity and should be eliminated.*

10. Research and monitoring activities can adversely affect biodiversity, particularly at the species and habitat levels. *Consideration must be given to whether the benefits of an activity outweigh the adverse impacts, and whether any precautions should be taken.* Consideration

must also be given regarding the qualifications of the investigator, and to the appropriateness of conducting the particular study within park boundaries.

Those scientific activities within parks that serve the preservation of biodiversity should be encouraged. Studies likely to be of greatest value are those which inventory and monitor existing diversity within parks. Because parks are often "island" refuges, studies that involve the collection of specimens or perturbation of natural populations and habitats should not only comply with all local, state, and federal guidelines, but should be regulated to the highest degree.

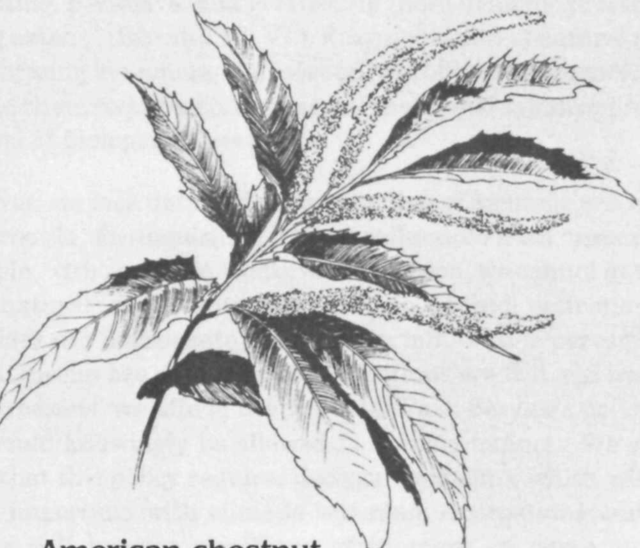
11. *Monitoring management actions and practices on other than target species is imperative to reduce impacts on biological diversity.* Some resource management policies, such as the historic policy guiding the removal of predators, have adversely affected biological diversity. Others, such as those guiding the restoration of historic scenes and the removal of exotic species, need to be reevaluated with regard to biological diversity. Additional programs should consider the active restoration of unique habitats and the reintroduction of missing indigenous species. Review and interaction between wildland managers and ecologists/scientists would be helpful.

12. Some investigation needs to be done to determine whether displaced native American populations may have presented a skewed picture to the first European explorers to an area. *Planned natural restoration should restore the native dominants, including all age classes, at natural densities and distribution patterns.* Attempts should also be made to restore physical parameters such as topography, drainage, and insolation patterns. (See also I, V.)

13. Mechanisms exist at all levels for parks to influence activities outside their boundaries. These include: *(1) international agreements, (2) cooperative efforts, (3) political and economic pressures, (4) education and public relations directed toward public and private interests with jurisdiction over adjacent lands, and (5) participation in public forums addressing land use, environmental policy and planning issues concerning surrounding lands.* (See also V, VI.)

SECTION V

Dynamic Processes



American chestnut
(Castanea dentata)

Section V. Dynamic Processes

Participants: Ted Case, Jim Cooley, Milford Fletcher, Lloyd Loope, Rob Peters, Bob Stottlemyer, Peter White.

The Problem

Biological diversity is dependent on the health and well being of natural ecosystems which are characterized by natural dynamic processes, such as extinctions, immigrations, catastrophic events, succession, and evolutionary change. Human influence on the biosphere is accelerating, pervasive, and is affecting these dynamic processes to an increasing extent. (See also IV, VI.) Fragmentation of natural areas and climatic warming are among the most critical of these influences, and our response to them requires that we assess the role of dynamic processes in the survival of biological diversity.

However, we lack data and understanding of dynamic processes, and we have trouble distinguishing human influences from "natural" ones. For example, with regard to "natural" extinction, we cannot at this point separate natural extinctions from human-caused extinctions. The baseline data are inadequate, and human influence is pervasive. Most important, species are slow to arise; extinctions are fast and irrevocable. For these reasons, we affirm the National Park Service's policy that no species should knowingly be allowed to become extinct. We recognize, however, that this policy requires decision guidelines which will become especially important with climatic warming; extirpations and possibly extinctions will become significant phenomena in parks, and whole species may shift their ranges. Evolutionary change is unlikely to keep pace with the rate of changing climates, nor are the areas between parks amenable to natural immigration between parks. National-scale leadership and cooperation are therefore critical.

In some cases, park size may constrain the outplay of natural dynamics. For example, fires from outside Sequoia and Kings Canyon National Parks may have been important historically in the dynamics of park ecosystems. Similarly, the hydrologic regime of Everglades National

Park is controlled outside the park itself. Clearly, reestablishment of natural dynamics within park boundaries alone will not always protect park ecosystems and biological diversity.

There are some good examples where the understanding of dynamic processes has been used effectively in park management to protect biological diversity, e.g., hydrology, barrier islands, fire management, and predator/prey interactions. In general, however, long-term baseline data have not been collected within an ecosystem context, with the result that many basic problems cannot now be addressed. Quality assurance and control plans are lacking, and there is no integrated plan to link data from genetics, populations, communities, and ecosystems.

With regard to natural dynamic processes, existing NPS policy is adequate for management purposes. However, the *implementation* of that policy is a problem. For example, the Park Service's science and resource management budget--both in terms of amount and allocation to programs--does not reflect the diversity of the agency's mission nor the complexity of tasks facing the parks.

Recommendations

1. *Research and resource management budgets must both be increased and sustained.* These two areas should not have to compete with each other, and long-term studies should not have to compete with short-term ones. As a percentage of the total budget, the NPS's research budget should be more in line with that of other land-managing agencies. (See also I, II, III.)

2. *Interaction between outside researchers and the NPS must be improved, and the focus of park science must be expanded to address national issues like biological diversity.* A national focus will further require a change in organizational structure from one which emphasizes response to local and often short-term problems to one which includes, for example, plans for quality control, quality assurance, and data management. (See also I, II, III, VI.)

3. *Regional planning and adequate coordination with surrounding land-managing agencies* must be carried out in order to protect biological diversity on a regional scale. (See also I, II, III, VI.) Active

management of experimental areas outside the park might be undertaken.

4. *The National Park Service should participate in a national network of Ecological Observatories* where data are collected on all aspects of biological diversity and changing environments.

5. *The National Park Service needs new tools (including models as predictors of change), well–conceived study designs, and coordinated inventory and monitoring linking biological diversity to an ecosystem–level context.* These strategies must be aimed at understanding the pattern and rate of dynamic processes. (See also II, III.)

6. It is unrealistic for the NPS to tackle this role alone; *priority should be placed on complementing existing programs* (e.g., LTERs), both within and outside the parks. An interactive process to identify and refine data analysis for sensitive processes and ecosystem components must be a high priority. (See also III, VI.)

7. *We must undertake studies to determine the history of past changes*--both human effects and long–term natural changes--to increase our understanding of their temporal and spatial scales.

8. *There is a need for research on the reestablishment of natural dynamic processes* where these are not now allowed to occur. Potential conflicts between the outplay of particular dynamic processes and the survival of particularly vulnerable species should be studied. (See also I, IV.)

SECTION VI

Integrating Parks into Larger Units

River otter
(Lutra canadensis)

Section VI. Integrating Parks into Larger Units

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The Problem

U.S. national parks are discrete units that have definable characteristics such as size, shape, and content, but they occur within a regional landscape context. Because park boundaries were generally set on the basis of other criteria, no park encompasses an entire functioning regional ecosystem. Park boundaries not only cut across important natural boundaries and phenomena, they occasionally impede them.

Unplanned and unregulated land-use changes outside park boundaries, including habitat utilized by migratory species, are increasingly responsible for the erosion of biological diversity within the parks. Yet little emphasis is currently placed on research and monitoring of events and processes that occur outside the parks but influence biodiversity within them.

According to a recent NPS survey, fully two-thirds of contemporary influences on national parks originate from outside park boundaries. (See also IV, V.) A growing number of these influences are regional, such as atmospheric pollution and land use changes; others, such as sea-level rise and climatic change, are global in scale. Human alteration of natural ecosystems has isolated every park, at least with respect to some of their species. These influences may affect natural processes responsible for maintaining biological diversity in ways that are often poorly understood.

Unfortunately, the collection of biological information essential for sound management has often been limited by the park boundary. Many managers lack the information to determine whether, or how well, elements of the park's biodiversity are being protected in adjacent areas or in the greater ecosystem of which the park is a part. Furthermore, as noted in several preceding sections, integrated regional inventories and coordinated long-term monitoring of biological diversity are often lacking or inadequate, in part because several federal agencies share parallel and sometimes overlapping authorities and congressional mandates for protecting biodiversity.

Recommendations

1. *Park managers should initiate and/or participate in local and regional forums* for planning of resource management issues to enhance and support park values, including biological diversity. (See also I, II, III, V.)

2. To ensure interagency cooperation, *a domestic task force should be established to provide leadership for planning and coordinating the implementation of a national strategy for maintaining biological diversity.* This activity should include the development of a *national information* base on the biogeographic distribution of protected areas and the representation and protection status of elements of biological diversity.

3. *Park managers should be encouraged to conduct cooperative research efforts outside park units* in areas that are known or presumed to enhance the protection and biological diversity of park resources. Each park should identify needed systematic or genetic studies of species, with priority on those species likely to be altered by human actions. Sharing expertise between agencies and joint funding should be encouraged. (See also I, II, III, V.)

a. In addition to cooperative gathering of information, *there should be regionwide coordination of data collection and management.* Common terminology, units, standards of measure, inventory procedures, ecological classification, and management descriptions are needed. NPS should conduct an inventory of existing biodiversity-related databases and convene a group of managers, scientists, and technical people to plan data management strategies. (See also II, III.)

b. *Park managers should identify the regional context necessary to maintain the long-term viability of biological diversity within units* *of the system.* Both General Management Plans and Natural Resource Management Plans should be oriented toward long-term ecological planning, and should specifically include strategies for cooperative management of diversity elements with other agencies and entities (including the private sector), opportunities for wildlife corridors, and other methods of integration with external ecological factors. (See also III, V.)

4. *Each park should conduct an individual assessment of the information it needs to enhance protection and monitoring of biological diversity.* Lists of species, subspecies, and ecotypes of flora and fauna, and plant communities which occur within the park/region should be developed. The NPS should adopt or develop a system to assign "rareness" and "threat" ratings to species which occur within parks; the rating system might be patterned after The Nature Conservancy's Natural Heritage Program. A comprehensive reference collection of flora and fauna should be maintained and used for scientific research. (See also II, III.)

5. To encourage research and education relating to biological diversity, *managers should cooperate with other agencies and organizations in planning and designating special areas* for protecting, inventorying, and monitoring biological diversity. These could include national natural landmarks, critical habitats for endangered species, research natural areas, core areas of biosphere reserves, and Long-Term Ecological Research sites. (See also I, III, VI.) In particular:

a. A new initiative should be undertaken to evaluate and strengthen the potential of the Natural Landmarks Program in the national biodiversity effort, particularly for long-term preservation and public education.

b. The NPS should work with other agencies to reactivate the Federal Committee on Ecological Reserves, and update its 1972 directory of sites.

c. In cooperation with the National Science Foundation, the NPS should aggressively pursue opportunities for developing proposals to establish Long-term Ecological Research sites in NPS biosphere reserve units, and for coordinating NPS research with existing LTER sites and other monitoring programs. (See also III, V.)

6. *Programmatic responsibility should be assigned for coordinating and implementing the provisions of various external legislative and administrative programs* that have the potential to enhance biological diversity and preserve specific habitats. These include federal programs like "swamp buster" and "sod buster," conservation easements on adjacent defaulted farm lands, state level programs such as "areas of critical concern" and various non game programs for acquiring additional habitat.

7. The magnitude of external threats to biodiversity within parks is likely to be greater for park units that are small and/or isolated from their former regional natural ecosystems. *Managers of these smaller and more biologically isolated units will need exceptional sensitivity to external threats and greater willingness to undertake active resource management when necessary.*

8. In cooperation with other agencies, universities, school systems, and nongovernmental organizations, *managers should expand efforts to foster public awareness of the value, requirements, and practice of conserving biological diversity and the role of individual parks.* Special efforts should be made to *document the knowledge of Native Americans* and other traditional users of biological diversity and to incorporate cultural knowledge in public education programs. (See also I, II, III, IV.)

9. *The NPS needs to provide park managers with training in biological diversity/conservation biology* so they can more easily evaluate outside actions that may affect park biodiversity and more effectively manage their own parks in a regional context. Training should also include appropriate regulations, tax policy, and cooperative mechanisms available for participating in local and regional forums. NPS resource managers and scientists should be encouraged to share technical assistance and advice with other protected area managers.

10. *The NPS should give priority to scientific and educational activities in biosphere reserves* so that each becomes a model for demonstrating the applications of conservation science and the value of conservation in its particular bioregion. (See also I, V.)

Use of NPS biosphere reserves for domestic and international comparative research, personnel exchanges, and professional training should be encouraged, strengthened, and expanded to institutionalize cooperation under the aegis of the Man and the Biosphere Program. The biosphere reserve concept and approach (as described in UNESCO's Action Plan for Biosphere Reserves) should be used as the basis for integrating parks into the larger region, regardless of whether the park has been officially included in the international network.

11. *Various techniques should be researched and evaluated to integrate biological reserves into the human–dominated landscapes within which they occur, thus increasing the effective size of biological reserves without necessarily increasing their absolute acreage.* These could include: (1) adjacent zones of cooperation, (2) animal dispersal and movement corridors, (3) bioregion boundary configurations, (4) strategic placement of reserve units, (5) allowing traditional resource uses in boundary zones, and providing incentives for surrounding resident people to preserve biodiversity.

12. *To enhance this integration into private sector lands, social science research should be conducted* to identify the sociocultural and economic considerations that facilitate or impede implementation of NPS biodiversity programs. Specific mechanisms such as private sector assistance incentives, cooperative agreements for resource use, conservation easements, and promotion of appropriate local zoning ordinances need to be researched.

13. *Research is also needed to verify and evaluate the impacts of surrounding land uses on the long–term biodiversity of conservation areas.* Research topics might include vegetation structure, species composition and turnover, population viability, etc. *Rational and credible criteria for determining and defining critical protection zones around parks should be developed.*

14. *Specific research should be conducted to identify degrees of biotic isolation of park units* from former contiguous biota. Such research will identify the relative urgency of and opportunities for public land consolidation, land exchanges, linking public lands, and establishing zones of cooperative use and management.

15. *The NPS should participate in developing the scientific basis for management strategies to maintain biological diversity in response to changes in regional and global climate and atmospheric pollution* and should encourage the use of NPS areas for scientific studies through the

International Geosphere-Biosphere Program. (See also I, V.) This research should address such issues as:

a. The worsening misalignment of legislative and bioregional boundaries and the potential near-term loss of relict and narrowly-distributed species;

b. Shifts in the location of ecotones and the high biological diversity they contain and the role of ecotones as bellwethers of global change; and

c. The role of atmospheric pollution as a contributing factor in the loss of biological diversity.

Summary of Recommendations

Legislation/Policy

1. Secure legislation to provide the National Park Service with explicit statutory responsibility to protect biological diversity (I, II).

2. Integrate this explicit biodiversity mandate with existing environmental protection laws and policies (I).

3. Fully implement the Service's existing inventory and monitoring policies; new standardized regionwide policies need to be developed and implemented (I, II, III, V). (See also Research Recommendations.)

4. Secure a mandate for restoration of extirpated or degraded ecosystems or their components (I, IV, V). (See also Management Recommendations.)

5. Institute a policy to eliminate commercial resource extraction as well as organized harvests of terrestrial and aquatic species (IV).

6. Increase and sustain both research and management budgets over the long term (I, II, III, V).

Management

Cooperative Strategies/Outreach

1. Develop a strategy for cooperation with landowners and other land and wildlife management agencies external to the park and for research, planning, and management activities. This should include initiating and/or participating in regional forums. Park managers should identify the regional context necessary to maintain long term viability of biodiversity (I, II, III, IV, V, VI).

2. Improve communication with the public about the importance of preserving biodiversity, the challenge of doing so, and the elements needed for success. Such communication should include documenting the

knowledge of Native Americans and other traditional users of biological resources. Interaction with the public could also take the form of using members of the public as volunteers in monitoring, research, and restoration efforts (I, II, III, IV, VI).

3. Establish a task force to provide leadership in planning and coordinating the implementation of a national strategy for the conservation of biological diversity (V).

4. Participate in developing the scientific basis for management strategies to maintain biological diversity in response to changes in regional and global climate and atmospheric pollution (VI).

5. Give priority to scientific and educational activities in biosphere reserves and use biosphere reserves for cooperative domestic and international research, exchanges, and training (I, V, VI).

6. Provide park managers with training in biological diversity and conservation biology and share technical assistance and advice with other protected area managers (VI).

Administration

7. Build accountability for the maintenance of biodiversity into the management and administrative systems of the NPS (I).

8. Assign programmatic responsibility to coordinate and implement the provisions of various external legislative and administrative programs that have the potential to enhance biodiversity and preserve specific habitats (VI).

9. Plan and designate special areas for protecting, inventorying, and monitoring biological diversity (VI).

10. Monitor management actions and practices on other than target species to reduce incidental impacts on biological diversity (IV).

11. Regulate park development and maintenance activities; always precede development with adequate inventory and monitoring (IV).

12. Control recreational use when it conflicts with the maintenance of biodiversity (IV).

13. Carefully weigh the risks and benefits of proposed scientific activities within parks, and restrict those that may adversely affect biodiversity (IV).

Management Specifics

14. Review and refine fire management plans as necessary. Institute prescribed burning programs based on the best scientific evidence of historical fire regimes (IV).

15. Review and modify water management plans where necessary and include considerations of biodiversity in developing any new water management plans (IV).

16. Consider the role of indigenous insect and disease outbreaks when determining management policies (IV).

17. Establish decision criteria to determine when intervention in natural processes is justified to conserve biological diversity (I).

18. Set clear standards to determine when biological diversity should be conserved in seminatural ecosystems (e.g., historic hayfields or wet meadows) or in parks focusing on cultural resources (I). Managers of smaller, more biologically isolated units must be exceptionally sensitive to external threats and willing to undertake active resource management where necessary (VI).

19. Begin planned restoration of extirpated or degraded ecosystems to restore native dominants where appropriate. All seeds and plantings should be of genetic stock specific to the park and the local area (I, IV, V).

20. Reduce the densities of harmful or detrimental exotic species within and around parks to a level where their influence is minimized and possibly eliminated (IV).

21. Eliminate grazing of domestic animals in the parks (IV).

Research

General Cooperative Research Needs

1. Begin an adequately funded servicewide inventory and monitoring program to be integrated into all appropriate NPS units. Protocols should include: (a) statistically sound sampling plans, (b) selection of appropriate taxa, (c) selection of appropriate abiotic elements, (d) use of available and new technology and evaluation of potential future technical developments, (e) standardized techniques, (f) peer review, (g) collaboration with other agencies and use of outside experts, (h) alternative funding sources, and (i) citizen volunteers as appropriate (I, II, III, V).

2. Establish long-term ecological studies in conjunction with other ecosystem research programs. Promote the synthesis and interpretation of these long-term studies and the testing of selected species' projections through the use of centralized information networks (III, V, VI).

3. Improve the interaction between outside researchers and the NPS, and expand the focus of scientific research to address national-level issues such as biodiversity (V).

4. Participate in a national network of ecological observatories for the collection of data on all aspects of biodiversity and changing environments. Create a national information base on the biogeographic distribution of protected areas, and the representation and status of elements of biodiversity (III, V, VI).

5. Research and evaluate techniques for integrating biological reserves into the human-dominated landscapes within which they occur. This will require research that will:

a. Verify and evaluate the impacts of surrounding land uses on long-term biodiversity of conservation areas;

b. Develop rational and credible criteria for determining and defining critical protection zones around parks; and

c. Conduct social science research to identify the socio-cultural and economic considerations that facilitate or impede implementation of NPS biodiversity programs (VI).

6. Develop new tools, including models, as predictors of change. Develop well-conceived study designs and coordinate inventory and monitoring procedures that link biodiversity to an ecosystem-level context (II, III, V).

Biodiversity and Population Viability Analyses

7. Develop a series of procedures for measuring, and criteria for evaluating, biological diversity (I).

8. Conduct Population Viability Analyses (PVAs) for a representative set of species whose long-term viability is at risk; use PVAs now where sufficient data exist (III).

9. Investigate the relationship between environmental and demographic variability (III).

10. Refine and integrate viability models to stress generality; minimize the demand for extensive or detailed data and the background required of users for effective application (III).

Other Research Topics

11. Conduct further research on the relationship between fire regimes and diversity in various biological communities (IV).

12. Continue research on the interaction between herbivores and plants, and synthesize existing literature on herbivory (IV).

13. Undertake studies to determine the history of past changes and studies of boundary problems and effects (V).

14. Identify degrees of isolation of park units from former contiguous biota (VI).

15. Conduct research on the reestablishment of natural dynamic processes where these are not now allowed to occur (I, IV, V).

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