Functions of Natural Science Research in National Parks

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Management of natural ecosystems is, at best, a poorly developed art. Scientific research is necessary to develop a basic understanding of ecosystems upon which to base management, to assess natural integrity of ecosystems (health), to identify causes of ecosystem disfunction, and to restore systems degraded by human activity. Conversely, national parks, as naturally functioning ecosystems, provide unique opportunities for advancing scientific knowledge.

Natural Science Research in National Parks

If managed as vignettes of primitive America, national parks can provide a number of values in addition to their classic roles as pleasuring grounds for recreation and emotional retreats from the stresses of modern, urban life. These naturally functioning ecosystems are environmental "miner's canaries," providing early warnings of impending disasters. They are ecological standards, or controls, against which effects of human activities on the biosphere may be measured. They are reservoirs of wild genetic material that protect biodiversity as investments in society's future. They provide opportunities to learn about the structure and function of natural systems and the processes that shape them. Nevertheless, if these values are to be realized, the scientific community must exercise every opportunity to conduct research in parks that utilizes these values or the ecosystems will be altered to provide more recreational exper-

iences at the expense of their natural functions and diversity.

In the near future, national parks may be the only places where human impacts on the biosphere may be detected early enough to prevent catastrophe. This is particularly true in the coastal zone, where 75 percent of the American people will soon reside and where other natural area management agencies are generally restricted to either marine or terrestrial portions of the biosphere. As an example, early detection of DDT contamination in marine food webs in Channel Islands National Park was one of the most important factors in preventing irreversible contamination of coastal ecosystems in general, and more specifically, extirpation of California brown pelicans in the United States.

In altered ecosystems, cumulative effects and synergism of multiple human influences make it virtually impossible to detect discrete causes of change or to evaluate system degradation. National parks can provide ecologically-independent units in which to test hypotheses and develop new approaches for managing and utilizing natural resources. For example, coastal fisheries management based on species-specific approaches to regulations using closed seasons, size limits, and gear restrictions has generally not been successful. Hypotheses regarding sizes and distributions of ecologically discrete management units like national parks need to be tested as ways to improve fisheries productivity and sustain yields.

National parks provide opportunities to study natural genetic variability and the dynamic evolutionary processes that produce and maintain it in the context of predation, competition, and other ecological factors. Parks complement the more static roles of zoological and botanical gardens in maintaining biodiversity, but neither approach alone will suffice to provide the understanding necessary to assure a safe, productive human environment. Research in both kinds of situations needs to be conducted in a compare and contrast mode. As national parks become increasingly isolated pieces of once large-scale natural communities, they will also become even more valuable as places to study the genetics and other attributes of small populations and test hypotheses on population biology and biogeography.

National Park Service Uses of Natural Science Research

In addition to these basic research topics, the National Park Service needs to conduct what may be termed "applied research" to achieve its mission. The primary natural resource mission of the National Park Service may be described as providing health care for selected examples of the nation's native ecosystems. In many respects, these park ecosystems are analogous to patients' bodies, and the National Park Service is analogous to a health care organization: both of which are designed to assure continued good health of their subjects. However, the present status of knowledge concerning ecosystem structure, function, and

dynamics is not much better than the state of knowledge of human physiology in 1628, when William Harvey first accurately described heart function and circulation. A basic understanding of ecosystems must be developed or we will continue to struggle blindly and ineffectively to search for ways to maintain and restore parks and the biosphere they represent.

Like medicine, natural resource management is an art practiced on a scientific basis. It requires a team of scientists working toward the same goal, healthy park ecosystems, with each contributing in their own way. They all follow the scientific method, i.e., hypotheses are formulated, tested, and revised based on test results. It is functionally important to recognize the distinct, but complementary, roles that various National Park Service professionals play in this endeavor. For example, resource managers act as family physicians for park ecosystems. They monitor ecosystem health with regular checkups. They recognize symptoms and diagnose illnesses, sometimes acute, sometimes chronic. They prescribe treatments and evaluate the results of those treatments. However, research scientists act as medical researchers. They develop new techniques for assessing ecosystem health. They identify new diseases and determine causative agents. They develop and test new treatments to cure or to mitigate illness. Park superintendents must also recognize that identifying and solving ecological problems in such extremely complex and poorly known systems as national parks is clearly an art and even management itself must be conducted as a scientific experiment.

As an ecological health maintenance organization, the National Park Service needs to conduct original research to learn how to monitor the health of park ecosystems, diagnose system illnesses, prescribe treatments to restore ailing systems, and seek ways to reduce threats and prevent system degradation. Basic knowledge of ecosystem structure and function is so rudimentary that research is required to: 1) develop methods of selecting and monitoring ecosystem components that will serve as vital signs of system health; 2) determine limits of normal variation for these components in order to identify conditions which warrant management action; 3) develop methods of restoring ecosystems; and 4) identify causes of system dynamics and disfunction. Most agency research is designed to address one or more of these topics.

Ecosystem Monitoring

Several approaches to developing long-term ecological monitoring programs are being tried in national parks. At Channel Islands NP in California, populations were selected as the basic ecosystem component to be monitored. Changes in population abundance, distribution, age structure, reproductive efforts, recruitment, growth and mortality rates, and phenology of over 400 taxa are measured regularly and used as indicators of ecosystem health. These organisms

integrate a wide variety of environmental influences such as disturbance, predation, competition, and nutrient availability. They express their responses to these influences as changes in easily measured and readily interpreted parameters of population dynamics. Some of these parameters, such as reproductive efforts and growth rates, are sensitive measures of subtle chronic stress that provide early warnings of impending disaster. Others, like age structure, permit reasonable projections of system health into the near-term future, just as a physician can describe the prognosis of an overweight, hypertensive patient. In addition, management controls frequently operate most effectively at the population level, making application of monitoring results straightforward. Population dynamics appears to be a promising approach to monitoring park ecosystems, but other approaches, such as inventories of biodiversity, and measures of energy flow and nutrient and constituent cycling also need to be more fully developed and tested for applications in national parks. A pilot park program on natural resource inventory and monitoring is currently underway in nine parks, the results of which may shed additional light on this subject.

Determine Normal Limits

Long-term data sets of ecosystem parameters are few and far between anywhere in the world. Without such observations, it is difficult to construct reliable models of system behavior or rationally determine when conditions warrant management intervention. Since it is virtually impossible to fund research projects for periods of time longer than three years within the existing National Park Service administrative system, it is not possible to develop such data sets in individual national parks in the course of normal research activities. Despite these constraints, a few outstanding examples of long-term data sets on populations of selected species have been developed that may be used to establish normal limits of variation for the systems in which they occur. Among these are the wolf and moose data from Isle Royale NP, Michigan, sooty tern information from Ft. Jefferson NM, Dry Tortugas, Florida, and water level, wading bird, and fishery resources at Everglades NP, Florida. On a Servicewide basis, air and water quality monitoring programs have been base funded and are beginning to develop a network of physical and chemical sampling stations and protocols, but no comparable biological monitoring program exists.

Restore Ecosystems

Most research efforts conducted by the National Park Service involve an attempt to restore some aspect of a natural system perturbed by human activity. Many projects seek to identify and develop methods for removing or mitigating effects of alien species introduced by man. Conversely, there are nearly as many efforts to restore extirpated or nearly extirpated native species. It is now clear that fire

is a powerful natural process in many ecosystems and has been significantly altered by human activities, but this knowledge is relatively new. Exemplary National Park Service research in the 1950s and 1960s at such parks as Everglades, Sequoia, and Kings Canyon documented the role of fire in forest ecosystems and dramatically changed management policies and actions. Considerable Service research and resource management efforts continue to pursue information on the role and effects of fire in natural ecosystems in efforts to restore and maintain naturally-functioning vignettes of primitive America. Restoration of ecosystems altered by extirpation of native predators, such as wolves and sea otters, requires scientific research to develop socially and ecologically acceptable strategies.

Identify Causes of Disfunction

Frequently park ecosystems are so stressed that serious disfunction is apparent even to the casual observer. In these situations management action seems imperative, but frequently symptoms, not causes, are all that are apparent without extensive basic research on system structure and function. Many management actions are taken to treat symptoms rather than seeking system understanding and conducting controlled experiments to determine causes. Eventually, these expedient, short-term solutions to fundamental ecosystem problems precipitate threat and crisis-oriented "crash" programs to "fix" the system. Since the 1980 *Threats to Parks* report, research priorities have been heavily influenced by resource threats and many projects funded from Servicewide programs address one or more threats in one or more parks.

Mitigate Threats

In addition to protecting and perpetuating natural ecosystems, the National Park Service must also protect the visiting public and provide access to parks. This mission frequently requires development of new knowledge to assure safe access without impairing park ecosystems. For example, knowledge of bear behavior and natural history has to be acquired through research before an adequate program of peaceful co-existence can be developed for park visitors and wild bears. This role of research may be described as providing innovative or unique solutions to management issues through the development of new knowledge.

Conclusions

The scientific community-at-large needs naturally functioning ecosystems to use as ecological standards, reservoirs of wild genetic material, and places to learn about the structure and function of natural systems and the processes that shape them. Realization of these scientific values of national parks often conflicts with recreational uses. The scientific community must assert its needs, demonstrate the validity of these needs through use, identify conflicts with other uses, and advocate management policies that will assure protec-

tion of naturally functioning ecosystems. The National Park Service needs to conduct scientific research to develop a basic understanding of park ecosystems and to use a scientific approach to park management. It is abundantly clear that laissez-faire management is detrimental to national park ecosystems and that management by blind trial-and-error is expedient but prohibitively expensive in the long-term. Continued treatment of the symptoms of threats to park ecosystems, without attention to underlying causes, will be no more successful than was the common 19th century practice of blood letting in curing the underlying causes of high blood pressure. The present level of scientific staffing and research funding in the National Park Service is sufficient only to identify the most grievous threats to park resources and respond in a reactive mode to a small proportion of them. Overcoming existing deficiencies in the basic understanding of ecosystem dynamics necessary to become proactive and efficient in addressing management issues will require a significant increase in long-term research funds and an agency commitment to excellence in scientific management.

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