Introduction

Biological resources are this nation's treasure. Their key attribute is that they are alive, and as living organisms they are, if properly maintained, renewable. They sustain Americans by contributing food, water, fuel, medicine, employment, recreation, and, especially, the splendor and wonder that inspire and nurture our spirits. Use of these resources, whether in consumptive ways such as logging, commercial fishing, hunting, and agriculture or in nonconsumptive activities such as hiking, birdwatching, sailing, and catch-and-release fishing, requires effective management that allows for all these uses and more while assuring that the uses are compatible with resource renewal. But effective management of complex life forms and systems demands scientific understanding.

Even a seemingly innocent hike in the woods has a range of potential effects, most likely minor, on the living resources in those woods. Simple footprints may lead to developing a path, or may even carry the beginnings of a colonizing species foreign to that place. The pathway, though, may halt nature's spread of a native plant, open a corridor for a migrant animal, or enable the first nonindigenous seed or insect to spawn a vast invasion unimpeded by natural controls. In such instances, native species could be in a sensitive stage of nesting or pollination, vulnerable to unanticipated disruption by the newcomer.

Most small, accidental incursions will fail because they occur in places and climates inhospitable to invading species, and most minor damage will have few effects because of the resilience of nature. But anyone familiar with nonindigenous species such as European starlings, kudzu, or zebra mussels knows that the competitive advantages of invaders can overpower their native hosts, particularly in stressed habitats. And we have all lamented the loss of species that could not bear the changes brought about in their habitats by such invaders. But if we understand components of the woods, including its plants and animals, the tolerance of its soils to disturbances such as compression, and what species use the woods for critical nesting habitat, we can effectively manage a resource so it can be enjoyed for generations. In short, our land and its water and the inhabitants of both can usually tolerate some change and survive, remaining vigorous and vibrant, as long as we understand what we are doing to them and how to protect the critical parts of the living, dynamic system they represent.

The use of natural resources is often significantly more intrusive than the passage of a lone hiker, however. Human needs may call for removal of acres of mature trees from a steep hillside that overlooks a stream in which salmon spawn. The logical construction path for a highway may take it directly through a large wetland that shorebirds use as wintering habitat. Our need for simple sustenance provides the impetus for continued removal of thousands of tons of marine life for seafood. In such cases, the scale of both potential effects and the scientific information needed to manage these activities so that a resource will continue to be renewable increases.

Widespread need for the scientific information vital for wise management of our biological resources was the force that influenced Bruce Babbitt, Secretary of the Interior, to establish the National Biological Service (NBS), now the Biological Resources Division of the U.S. Geological Survey (USGS). As one of his first assignments to NBS, Secretary Babbitt asked its scientists to produce a report that would

provide the first comprehensive summary of the status and trends of our nation's biological resources. The report was to be scientifically accurate but written and presented so that it could inform the general public in straightforward, nontechnical ways. The goal was to synthesize existing information for scientists and resource managers, policy makers, and the general public. If this report, *Status and Trends of the Nation's Biological Resources*, accomplishes its intended purpose, it will be an important contribution to the understanding of the condition of biodiversity on a national scale (see box on Organization of the Report).

A tremendous amount of information on habitats and organisms from each region of the country can be found in these two volumes. The book's authors explore the major factors affecting biodiversity and biological resource health and how these factors affect our regional biological resources or our management of them. For example, the remaining individuals of a species can be so limited in number and by available habitat that a single natural process can dramatically reduce its population, such as the way Hurricane Hugo drastically reduced the numbers of endangered Puerto Rican parrots. An example of how our understanding of biological processes has led to effective resource management is that regulations prohibiting the use of certain contaminants have enabled eagles, ospreys, and pelicans to come back from the brink of extinction across the country. In the Northeast, changes in land use have allowed forests to return in many places, thereby increasing habitat for numerous woodland species. The unhealthy and declining status of so many aquatic organisms in the Southeast is the result of the high degree to which rivers in that region have been dammed, channelized, or negatively affected by activities in the watershed.

Similarly, improved transportation and industrial technologies have not only shrunk the worlds of trade, commerce, and tourism, but they have also removed geographic and economic barriers, sometimes with unintended biological effects. Many nuisance aquatic species, for example, have gained entry to the Great Lakes, causing, in some instances, devastating problems for native species such as fishes and mollusks. Also, atmospheric changes caused by certain industrial technologies have the potential to alter many populations whose ranges are limited by climate and habitat availability and hence cannot "escape" such atmospheric changes.

As you read this report, you will also find examples of resources that nearly collapsed under the cumulative pressure of several factors. For example, lake trout were eliminated from four of the five Great Lakes, surviving only in Lake Superior. These fish succumbed to the pressures of severe overharvest by commercial fishermen, as well as to predation by the sea lamprey, a parasitic nonindigenous species that entered the Great Lakes through the Welland Canal (see box on Sea Lamprey in the Great Lakes chapter). While these two forces were reducing stocks of adult lake trout, the trout's reproductive capacity was greatly compromised by chemical contaminants and degraded habitat. Such relationships among the forces that cause change and the biological resources themselves are themes repeated throughout the report.

This report synthesizes information about the status and trends of America's natural resources, and it represents the combined knowledge of hundreds of experts who served as authors or reviewers. Yet even with the extensive information presented in these chapters, the information available to describe the status and trends of many organisms is extremely limited. The paucity of scientifically credible population data that would enable strong statements to be made about the status and trends of many biological resources is of great concern. It is essential to realize that these data provide more than just information about the health of a particular population or resource. They also provide a basis for assessing the sustainability of biological resources and the effectiveness of current resource management policies and strategies.

Why is there not more known about the status and trends of our biological resources? The federal government spends about $600 million a year on environmental monitoring, but the vast majority of these funds are dedicated to measuring attributes of air, water, soil, and habitat trends. Substantial trend information is only found on birds, some game animals, and commercially exploited species. And much of the information concerning exploited species comes from the harvest activity itself and is not independently measured. Thus, the limited information itself sometimes reflects the biases and limitations of the practitioners. In contrast, the information derived from objective scientific monitoring is not judgmental—it has no preconceived outcomes.

Multiple reasons exist for this dearth of information on the status and trends of animals and plants. Scientifically sound population status and trend information can only be obtained through monitoring programs. Monitoring information is developed *by using repeated measurements at regular intervals over a long time* and *using the same standardized methods to make those measurements*. For monitoring populations, the repeated measure must indicate the relative abundance of target species.

Organization of the Report

This report attempts to achieve Secretary of the Interior Bruce Babbitt's vision of a comprehensive summary of the status and trends of our nation's biological resources. The report describes the major processes and factors affecting biological resources, and it treats regional status and trends. Authors of the chapters and boxes in this two-volume report were drawn from federal and state agencies, universities, and private organizations, reflecting the U.S. Geological Survey's national partnership approach to providing comprehensive, reliable information about our biological resources. Following scientific tradition, each chapter and box was peer-reviewed by anonymous scientific reviewers.

The first seven chapters in Volume 1 describe the *major factors affecting biodiversity and biological resource health*. The aim of these chapters is to promote an understanding of the reasons for the current conditions of resources and the biological and physical relationships among the different parts of ecosystems. The first chapter, an essay by ecologist Steward Pickett, describes in some detail the natural processes affecting our nation's ecosystems. Other chapters in this section cover subjects such as contaminants, land use, water use, nonindigenous species, climate change, and harvest. Yet other chapters—on disease, tourism, management practices, and even politics, for example—could have been usefully added. This report does not dismiss such factors; it offers chapters on those forces that were judged to represent the most significant ones affecting our biological resources.

The remainder of the chapters in Volume 1 and Volume 2 explore how these natural and human-induced factors have led to the *condition or status of regional biological resources*; the chapters also provide information on *biological resource trends*. These chapters are drawn from existing information. Authors were asked to "tell a story" about the regions they describe and to document findings with data. Other than this guideline and a basic outline for the scientists to follow, there were few rules or limitations. Thus, the style in the end product reflects the ideas, the insights, and the great variety of approaches these ecological experts used in each chapter. Their varied emphases also reflect the relative importance of changes occurring in the conditions of biological resources in different geographic areas. The professional insight of these scientists is critically important in the regional chapters because there are so few biological resources for which comprehensive, substantive, scientific status and trends data are available.

Volume 1 ends with a chapter on coastal Louisiana and Volume 2 begins with a chapter on grasslands. At the end of Volume 2, readers will find a glossary, an appendix of scientific and common names for organisms mentioned in the report, and an index to both volumes.

Monitoring must occur at regular intervals for a significant number of years because of the variable nature of animal and plant populations and their sensitivity to a variety of conditions. Short-term monitoring is of limited value because annual fluctuations in populations may reflect such variables as precipitation patterns, temperature regimes, predator populations, or natural cycles. Consequently, long-term trend analysis is essential to reliably separate this natural variability from changes in a population that may require investigation or special management strategies. The frequency and duration of monitoring that is needed to provide usable information on population trends depend on the species being monitored. What may be a significant number of years for monitoring insects that have a life span of a year or less may be a meaningless period for monitoring sea turtles or lake sturgeon, which are species that require decades to reach reproductive maturity. Likewise, some plant species survive hundreds or even thousands of years, which means that generations of human study may be required before we even approach an understanding of the life patterns of these strands in nature's fabric. As with sampling methods, meaningful time periods for monitoring require a thorough understanding of an organism's life history and ecology.

In monitoring, scientific methods must be used that have been technically validated as effective for whatever organism is being monitored and that have been standardized across the program. If methods are improved as technology changes, we must still demonstrate comparability to the old methodology. At present, this characteristic is somewhat limiting because relatively few established methods now exist for accurately monitoring populations. Each organism creates its own set of monitoring problems because of its unique behavior, habitat requirements, or identifying characteristics. In some cases, even taxonomic identification may be problematic, such as when a plant species can only be identified when its flower is present. Much of the national-scale environmental monitoring is conducted by using remote sensing, satellite imagery, or other mechanical systems that enable automated data collection. This type of monitoring, however, is suitable for only a few species of plants or animals because the information such monitoring provides is generally at a landscape level and does not reveal enough about local changes in biological diversity.

Two misguided perceptions perhaps have limited the amount and kind of biological monitoring now conducted. One perception is that such monitoring may lead to overregulation. In reality, however, status surveys and monitoring have often allayed rather than heightened fears about wild animals and plants, particularly imperiled populations. Although most fears are in response to the possibility of perceived over-regulation, experience has shown, in fact, that the opposite is true: regulations tend to be tighter when the knowledge base is limited. For example, regulations that reduce human health risks often incorporate large margins of safety factors where uncertainties exist. For the most part, wild populations have a tendency to increase both in number and in range. In addition, increased scientific understanding of our biological resources can only lead to proactive management strategies that often prevent the need for further regulations.

A second unfortunate perception is that monitoring is less scientifically challenging than other scientific research, resource management, or any of the technical roles of the environmental scientist. Because of the repeated nature of monitoring activities, the field is viewed by some as being less creative or ingenious, thereby discouraging some scientists from pursuing monitoring in their professional careers.

The need for effective monitoring programs and the information they provide has never been greater. In *A Biological Survey for the Nation*, the National Research Council (1993) proposed a research agenda and identified a number of critical issues that NBS (now the Biological Research Division of USGS) would provide information to address. To achieve preservation of the "nation's biological heritage, . . . extensive information on the current status and trends in distribution and abundance of species" is needed, the report stated. Similarly, the President's Council on Sustainable Development (1996) recommended long-term scientific study to address the loss of biodiversity in this country. The Interagency Ecosystem Management Task Force (1995) recommended that agencies require a monitoring component as an integral part of all ecosystem efforts, that agencies develop common monitoring and evaluation standards, and that policy makers commit the adequate resources to conduct the long-term monitoring necessary for successful management. Such a program, though, must maintain its funding through periods of budget cutting and downsizing while competing with "new" and often more overtly "interesting" scientific ideas. Additionally, the critical need for longevity in a monitoring program mandates that it not rely on a single individual: a monitoring program must be designed to withstand the loss of individual scientists and changes in administrative management.

Yet even with substantial new investments in monitoring plant and animal populations, we would still only have status and trend information for an extremely small percentage of our nation's species. Fortunately, not all species need to be monitored. Recently, the concept of ecosystem management has gained credibility and favor over a species-by-species management strategy. Because an ecosystem management strategy protects biodiversity of entire ecosystems instead of just select species and their microhabitats, this strategy should be promoted despite the limited number of tools now available for measuring ecosystem health. And although population monitoring information is species-specific, there is a relationship between trends in species—particularly indicator or keystone species—and healthy, functioning ecosystems. Thus, increased monitoring of plant and animal populations is essential to ecosystem management. Monitoring of habitat extent, ecosystem type, and habitat quality also needs to be expanded. Some of this information is available from existing programs; the real lack of information is in organism population trends.

Developing status and trend information on enough species to understand ecosystem dynamics and effectively manage our nation's natural resources is sufficient, but monitoring information must be improved so that it accounts adequately for at least keystone species and representative members of each community and habitat type. Even as this report goes to press, a significant proportion of the freshwater fauna of this country, particularly in the Southeast, is imperiled (The Nature Conservancy 1996), and Hawaii's unique assemblage of species is rapidly being lost: the Hawaiian Islands have lost more than 50% of their birds, perhaps 50% of their plants, 90% of their native land snails, and an unknown percentage of their terrestrial insects (see chapter on Pacific Islands; also see LaRoe et al. 1995).

To be effective stewards of our nation's complex life forms and systems, it is critical to advance our scientific understanding of our biological resources. This report assembles information from thousands of sources and presents the first national synthesis of our knowledge concerning the status and trends of these resources. Because the authors did not have all the scientific information they would have liked for an assessment of this nature, and given the breadth of this report, there will be some missing pieces. Overall, though, I believe this report provides a much-needed summary view of the nation's biodiversity and is an important contribution to our understanding of our biological resources on a national scale.

Peter H. Raven
Missouri Botanical Garden
P.O. Box 299
St. Louis, Missouri 63166-0299

Cited References

Interagency Ecosystem Management Task Force. 1995. The ecosystem approach: healthy ecosystems and sustainable economies. Volume 1. Overview. Interagency Ecosystem Management Task Force. 55 pp.

LaRoe, E. T., G. S. Farris, C. E. Puckett, P. D. Doran, and M. J. Mac, editors. 1995. Our living resources: a report to the nation on the distribution, abundance, and health of U.S. plants, animals, and ecosystems. U.S. Department of the Interior, National Biological Service, Washington, D.C. 530 pp.

National Research Council. 1993. A biological survey for the nation. National Academy Press, Washington, D.C. 205 pp.

President's Council on Sustainable Development. 1996. Sustainable America: a new consensus for prosperity, opportunity, and a healthy environment for the future. President's Council on Sustainable Development, Washington, D.C. 186 pp.

The Nature Conservancy. 1996. Troubled waters: protecting our aquatic heritage. S. Flack and R. Chipley, editors. The Nature Conservancy, Arlington, Va. 17 pp.