Saving Biological Diversity

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Gerald R. Visgilio · Diana M. Whitelaw
Editors

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Balancing Protection of Endangered Species and Ecosystems

Springer

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Preface

The Goodwin-Niering Center for Conservation Biology and Environmental Studies at Connecticut College is a comprehensive, interdisciplinary program that builds on one of the nation's leading undergraduate environmental studies programs. The Center fosters research, education, and curriculum development aimed at understanding contemporary ecological challenges. One of the major goals of the Goodwin-Niering Center is to enhance the understanding of both the College community and the general public with respect to ecological, political, social, and economic factors that affect natural resource use and preservation of natural ecosystems. To this end, the Center has offered six conferences at which academicians, representatives of federal and state government, people who depend on natural resources for their living, and individuals from non-government environmental organizations were brought together for an in-depth, interdisciplinary evaluation of important environmental issues. On April 6 and 7, 2007, the Center presented the Elizabeth Babbott Conant interdisciplinary conference on *Saving Biological Diversity: Weighing the Protection of Endangered Species vs. Entire Ecosystems*. The Beaver Brook Foundation; Audubon Connecticut, the state office of the National Audubon Society; the Connecticut Chapter of The Nature Conservancy; Connecticut Forest and Park Association and the Connecticut Sea Grant College Program joined the Center as conference sponsors.

During this two-day conference we learned about conservation and endangered species from a wide range of perspectives. Like all of the conferences sponsored by the Goodwin-Niering Center, this conference was broadly interdisciplinary, with presentations by economists, political scientists, and conservation biologists. Bryan Norton, Professor of Philosophy, Science and Technology at Georgia Institute of Technology, gave the keynote address *Evaluation and Species Preservation*, followed by the first session in which we examined the effectiveness and economics of endangered species protection. The second session focused on efforts to sustain biological diversity in entire ecosystems or across regional landscapes. The third session emphasized the best methods for protecting biological diversity on a global scale.

The conference provided a broad overview of our current understanding of how to prevent extinction and sustain biological diversity. The audience included concerned citizens, NGO representatives and policymakers, and students and faculty from Connecticut College and other universities. This book, *Saving Biological Diversity: Balancing Protection of Endangered Species and Ecosystems*, is based on the papers presented at the conference.

The Editors

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We greatly appreciate the financial support provided for the conference by Dr. Linda Lear (Elizabeth Babbott Conant Endowment); Audubon Connecticut, the state office of the National Audubon Society; the Connecticut Chapter of The Nature Conservancy; Connecticut Forest and Park Association; the Connecticut Sea Grant College Program; the Marjorie Dilley Fund; the Beaver Brook Foundation; the Connecticut College departments of Anthropology, Biology, Botany, Economics, Government, Philosophy; the Connecticut College Arboretum; the Environmental Studies Program; and the Office of the Dean of Faculty. Organization of this conference was only possible thanks to the ongoing support of the A.W. Mellon Foundation for the Goodwin-Niering Center.

We especially thank Patrick Comins, Director of Bird Conservation, Audubon Connecticut, and Adam Whelchel, Director of Conservation Science, The Nature Conservancy, for their assistance in planning and presenting the conference. We are grateful to the following faculty, staff and students of Connecticut College for their assistance in a number of ways including planning and carrying out the conference and writing, reviewing, editing and proofing chapters for this book: Robert Askins, Professor of Biology; Anne Bernhard, Assistant Professor of Biology; Jane Dawson, Professor of Government; Glenn Dreyer, Arboretum Director; Douglas Thompson, Professor of Geophysics; Derek Turner, Associate Professor of Philosophy; Gerald Visgilio, Professor of Economics; Diana Whitelaw, Associate Director of the Goodwin-Niering Center; Mary Villa, Center Assistant; and David Hecht ’07, Sara Jayanthi ’07, Christine Monahan ’07, Ceileigh Syme ’06, Jesse Taylor-Waldman ’07, Center students.

During the preparation of this book, we greatly appreciate the assistance of many reviewers including: Peter Auster, Nels Barrett, MaryAnne Borrelli, Patrick Comins, John Gates, Brian Heninger, Chad Jones, Joan Trial, and John Volin.

Finally, we are most grateful to all the contributing authors for their patience, understanding and professionalism during the long process of responding to comments and recommendations received during the review and editing phases of this book.

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Robert A. Askins is Professor of Biology and Harrison Director of the Goodwin-Niering Center for Conservation Biology and Environmental Studies at Connecticut College. Askins received his B.S. from the University of Michigan, and his M.S. and Ph.D. from the University of Minnesota. He teaches courses in ecology, animal behavior and ornithology. He is nationally recognized for his research on the ecology and conservation of birds in North America, Japan and the West Indies.

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David A. Evans is an Economist in the U.S. EPA's National Center for Environmental Economics. He holds a Ph.D. from the University of Maryland, an M.A. from the University of Illinois, and a B.A. from Hiram College. His research interests include normative and positive analyses of regulatory design and the use of stated preference methods. He also performs and evaluates economic analyses that support proposed federal air quality regulations.

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David R. Foster is an ecologist and Director of Harvard Forest at Harvard University where he has been a faculty member in the Department of Organismic and Evolutionary Biology since 1983. He has his M.S. and Ph.D. in Ecology from the University of Minnesota and was an undergraduate major in Botany and Religious Studies at Connecticut College. Foster is the Principal Investigator for the Harvard Forest Long Term Ecological Research program funded by the National Science Foundation.

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Kathryn L. Kennedy is the President and Executive Director of the Center for Plant Conservation, which coordinates and assists development of hands-on plant conservation programs in a national network of 36 participating institutions. Kennedy has her Ph.D. from the University of Texas at Austin working in systematics and evolution, and her M.S. from New Mexico State University working in plant ecology. Her career in federal and state agencies as well as non-profit organizations has focused on the planning and implementation of restoration work for imperiled plants.

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Bryan G. Norton is Professor of Philosophy, Science and Technology in the School of Public Policy, Georgia Institute of Technology and author of several books including: *Sustainability: A Philosophy of Adaptive Ecosystem Management* (University of Chicago Press, 2005). His current research concentrates on sustainability theory and on spatio-temporal scaling of environmental problems. Norton has his Ph.D. from the University of Michigan.

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Gerald R. Visgilio is Professor of Economics and on the faculty of the Goodwin-Niering Center for Conservation Biology and Environmental Studies at Connecticut College. His research and teaching interests include an economic analysis of environmental and natural resource policy, environmental law, environmental justice, and antitrust law and policy. He earned his B.A. from Providence College and his M.S. and Ph.D. from the University of Rhode Island. Visgilio co-edited *Our Backyard: A Quest for Environmental Justice*, which was selected by *Choice* as an Outstanding Academic Title in Science and Technology in 2003, *America's Changing Coasts: Private Rights and Public Trust* in 2005 and *Acid in the Environment: Lessons Learned and Future Prospects* in 2007.

Diana M. Whitelaw is Associate Director of the Goodwin-Niering Center for Conservation Biology and Environmental Studies at Connecticut College where she coordinates the Certificate Program in Environmental Studies. Whitelaw co-edited *Our Backyard: A Quest for Environmental Justice*, which was selected by *Choice* as an Outstanding Academic Title in Science and Technology in 2003, *America's Changing Coasts: Private Rights and Public Trust* in 2005 and *Acid in the Environment: Lessons Learned and Future Prospects* in 2007. She earned her M.S. in Environmental Science from the University of New Haven and her Ph.D. from the University of Connecticut.

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Chapter 1
Saving Biological Diversity: An Overview

Glenn D. Dreyer

The conservation movement in North America emerged in part due to the shock of the extinction of the passenger pigeon and the near extinction of the American bison, species that had once been considered too numerous to be depleted. By the 1960s, a broad consensus emerged in the United States that species should not be driven to extinction by human activity. Since then, however, the Endangered Species Act and major programs to restore endangered and threatened species have become controversial. Private property rights advocates claim that endangered species protection hampers economic activity and land development to an unreasonable extent. At the same time some conservationists are concerned that too much money and effort are devoted to endangered species, diverting efforts from protection of entire ecosystems that support numerous species. They argue that given the limited resources available, preventing common species from becoming rare is the most effective long-term strategy. Defenders of endangered species programs claim that protecting endangered species usually entails protecting entire ecosystems, and endangered species can serve as effective symbols to rally support for ecosystem protection.

Saving Biological Diversity: Balancing the Protection of Endangered Species and Ecosystems seeks to emphasize the interplay between the science and policy of species protection. We have chosen to take a broadly interdisciplinary approach by focusing on such important topics as the effectiveness and economics of endangered species protection, efforts to sustain biological diversity in entire ecosystems or across regional landscapes, and the need to protect species diversity on a global scale. Our book is a synthesis of the views of economists, political scientists, resource managers and conservation biologists on a wide array of species protection issues. In a single book we could not hope to address the myriad species, habitats, ecosystems, conservation issues and political systems worldwide that a truly comprehensive treatment would require. Instead we present chapters illustrating a wide range of problems and solutions as they are seen by people who work in an array of disciplines and professions. Since our authors come from different academic traditions, the editors have chosen to tread lightly on preferred writing and referencing styles. While this results in some distinct stylistic differences between those authors with a legal background and those with scientific training, it does not detract from the communication of important ideas.

Our goal for this book is to engage a wide audience that includes researchers, concerned citizens, regulators, conservation managers and policy analysts. *Saving Biological Diversity* may also serve as a book of readings for courses in conservation biology, environmental studies, or environmental policy. We believe that the juxtaposition of

R.A. Askins et al. (eds.), *Saving Biological Diversity*,

views from many different disciplines will engender further discourse on how best to save biological diversity.

The following questions are offered to illustrate the issues that may be addressed by groups such as faculty and students, conservationists and legislators, and scientists and policy analysts who use this book as a source:

1. How should we define the term "biodiversity?"
2. How should we characterize and measure the *value* of biodiversity?
3. Should we focus on the protection of individual species or entire ecosystems, or a combination of the two?
4. What are the important economic issues pertaining to endangered species protection? How do we place a value on ecosystem improvements?
5. How can we establish a biodiversity conservation system that includes all major ecosystem types? Given the global scope of the loss of biodiversity, how can we be sure that we are not overlooking ecosystems that are quickly disappearing?
6. Are large-scale, ecosystem preservation efforts effectively protecting a high proportion of North America's imperiled plants? Or the world's most imperiled ecoregions?
7. Can a focus on protecting the particular habitat features needed by a single species result in effective protection of other vulnerable species or entire ecosystems?
8. How can we assure protection of species that migrate between regions? How can conservation programs be coordinated across state, provincial and national boundaries?
9. How can we restore biological diversity when the genetic uniqueness of some local populations has been lost?
10. Is the most effective strategy to focus on protection of large vertebrates to gain popular support for habitat protection and restoration that also benefits many less conspicuous and well-known species?
11. What particular challenges do resource managers and legislators face when designing protection measures for marine environments? Is enough attention being focused on marine ecosystems?
12. What size should a preserve be to effectively conserve local or regional biological diversity over the long term despite anticipated changes in the climate and in regional land use?
13. What challenges are faced when ecosystem restoration is attempted at a massive scale with multiple partners and stakeholders?
14. How does local land preservation affect global problems such as climate change and loss of biodiversity?
15. How can grassroots conservation efforts in less developed countries be supported by conservationists in more prosperous places?

Part I. Protecting Populations of Particular Species

In a truly interdisciplinary fashion, Part 1 includes the perspectives of a philosopher, a lawyer, an economist and three biologists. One of the common themes of these chapters is the U.S. Endangered Species Act of 1973 (ESA), which is not surprising

given the species level focus of this section and the U.S. origin of the authors. But plants and animals do not recognize political borders, and the basic issues raised by enforcement of the ESA will also arise wherever endangered species occur.

We begin with a chapter by philosophy professor Bryan Norton that explores, in the context of the ESA, what is meant by "biodiversity," and how its value can be characterized and measured. While the ESA focuses on the protection of individual species, this is generally understood as a proxy for an attempt to slow the rapid impoverishment of the biological world in general. The ideal definition of biodiversity must function in the very different contexts of scientific research and human-value based policy, and indeed must bridge these two worlds. Norton reviews how biologists define the term diversity, and finds that some definitions are based on inventories of organisms and others on difference measures. Fortunately, he does not find that disagreements about how to define diversity necessarily hinder conservation action. He includes a discussion of the importance of effective communication between scientists and policy makers, suggesting that more general terms (such as "web of life") might be helpful.

Is the species-level protection envisioned by the U.S. Endangered Species Act adequate? Did Congress mean to include habitats and ecosystems as well as the populations of endangered species in its attempt to preserve biodiversity? In Chapter 3, environmental law professor Karin Sheldon argues that the ESA does not specify an ecosystem approach to preservation primarily due to the approach to conservation at the time it was written in the early 1970s and the lack of subsequent revision. She begins with a review of the main features of the ESA, including "the list" of mandated actions for endangered species: designation of critical habitat, conservation and recovery, consultation, a ban on "taking," and reintroduction. At a time when habitat destruction is thought by most scientists to be the most significant threat to endangered species, one would expect regulations to rely heavily on an ecosystem approach. Sheldon argues that there are multiple benefits from using an ecosystem approach both for the agencies charged with implementing the ESA and for the species and ecosystems the Act is intended to protect. She concludes with thoughts on the need for, and possible implementation of, a national land conservation system to meet biodiversity preservation goals. How to choose lands to preserve and innovative approaches to set aside adequate acreage are further discussed in Chapters 10 and 12.

In Chapter 4, Gardner Brown reminds us that economists have much to contribute to the conservation of endangered species, especially because they realize that species have significant non-market value. Although the language of the Endangered Species Act calls for the protection of all species regardless of costs, Congress annually fails to provide sufficient funds for such protection. A better approach, from an economist's perspective, involves seeking the lowest cost way to save the most species, or maximizing the number of species saved given budget constraints. Brown goes on to discuss what he views as the most significant economic concepts for species conservation. These include "opportunity cost," which accounts for the value of resources in their best alternative use. The concept of opportunity cost forces society to deal with the issue of costs not only in terms of their monetary value but also in terms of their forgone alternatives. In this context, the cost of alternative approaches to species conservation may be related to trade-offs involving other species. Other significant concepts are recognizing the fact of diminishing returns as more resources are applied to species protection; acknowledging that not all species can be saved; understanding

that people act in their own interest; and the need for developing ways to quantify the public's valuation of non-market goods, such as many biological species. Chapter 9 provides a related discussion and an example of methods to quantify the public's willingness to pay for environmental improvements.

Many plant species in the United States are severely threatened. Unfortunately, as botanist Kathryn Kennedy points out in Chapter 5, while about half of the species listed under the ESA are plants, they receive only about 5% of the funding for recovery and restoration. After summarizing the value of plant life to ecosystems and human culture, she reviews the status of plants of conservation interest and estimates that nearly 25% of the U.S. flora is vulnerable or imperiled. There are many inequities in the U.S. conservation effort, which tends to provide much more funding, research, management and other resources for animals rather than plants. The non-profit Center for Plant Conservation has created a national network of botanical institutions working in partnership with government agencies to secure and restore imperiled plants both in the field and in botanical gardens and seed banks.

Next we turn to an example of a species listed as endangered in both the United States and Canada, the beach-nesting Piping Plover. Conservationist Scott Hecker explains in Chapter 6 how applying measures to protect and recover one bird species can have a very broad affect on associated species and habitats. Hecker gives the specific history of efforts in Massachusetts that involved cooperation among various federal, state and local government agencies and private organizations. As protection techniques evolved from simple fencing around nests to restricting nearly all vehicle access to beaches during breeding season, a number of other previously declining species of plants and animals also began to recover. Piping Plover preservation became an effective umbrella for saving Atlantic Coast barrier beach habitat and the Massachusetts model is becoming known as a classic conservation success story. Now the challenge has moved to protecting Piping Plover habitat during the non-breeding season, most of which is in the United States. If successful, this will provide another umbrella of protection for many other species.

Arguably the best-known fish in the Northern Hemisphere, the Atlantic salmon is another migratory animal that has declined to the point of requiring federal protection in the United States. Biologist Stephen Gephard explains that concerted recovery efforts for this fish in New England, begun before the ESA, have included habitat protection and manipulation, particularly the removal of dams or the construction of "fishways" to allow migration between the Atlantic Ocean and spawning areas in gravelly headwater streams. In contrast to the previous example, conservationists have also developed captive breeding programs that now utilize increasingly sophisticated genetic fingerprinting of individuals. Unfortunately the population trends in the United States and elsewhere have been downward since the mid 1980s, and the Atlantic salmon was listed under the Endangered Species Act in 2000. Population restoration efforts in New England continue, and have evolved from single species management to programs that include all diadromous fish.

Part II. Protecting Regional Ecosystems

The goal in Part I was to focus on particular rare species and the federal legislation that mandates their protection At this point it should be clear that any discussion of

single species conservation inevitably leads to issues at larger scales. In Part II we step up from concern about populations of particular species to an emphasis on ecosystems and regional landscapes.

We begin with Chapter 8 on ocean conservation in the United States from a policy and management viewpoint. Environmental advocate Susan Faraday compares marine ecosystems to terrestrial ecosystems, and finds them fundamentally different both as physical habitats and in terms of the level of environmental awareness and protection. Numerous studies point to the need for a comprehensive, ecosystem-based approach to marine conservation in place of the patchwork of legislation and regulation now in effect. Protected areas, while relatively successful for preserving ecosystems on land, have not been used nearly as often, or as successfully, in the oceans. Marine protected areas established under the National Marine Sanctuaries Act of 1972 provide illuminating examples of the tension between protection and multiple use goals in sanctuary management, as well as the potential for new and more effective conservation directions. Faraday argues for replacing the current, ad-hoc methods of determining compatible uses within marine sanctuaries by developing a clear vision of the goals of each sanctuary using transparent, standardized methods for making decisions about which activities should be restricted, an approach that is used successfully to manage terrestrial habitats.

In Chapter 9, Economist David Evans and his colleagues provide an argument for placing value on "non-use" items that, in a conservation framework, may involve the existence of species or the protection of habitats that we may never "use" or even see. Society values such resources, even though many of us do not or will not actually use them. This non-use value simply reflects the benefit to society from the continued existence of environmental resources, such as an individual species or an entire ecosystem. Evans and his colleagues then detail the methodology of a stated preference approach to determine "non-use value," which was used to estimate how much people are willing to pay for environmental improvement. They provide an example of this approach with a survey to estimate how much New York State residents would pay to improve the aquatic ecosystem of lakes in Adirondack Park, which has been damaged by acid deposition. They conclude with some thoughts as to how these methods can help conservationists select appropriate protection strategies that will be approved by policy makers.

Early in any ecosystem preservation program, questions arose concerning how much habitat and what type of habitat are needed to meet goals. In Chapter 10 ecologist Mark Anderson describes a procedure for answering this question, using forest ecosystems in the northeastern United States as an example. His methodology for determining adequate preserve size is based on protecting a large enough area to accommodate natural disturbances at various scales as well as viable populations of species that require large areas of habitat. Important conditions of the land include biological legacy features and the amount of unfragmented, interior forest. He also notes that natural or semi-natural landscapes surrounding the preserves provide a buffering effect and act to interconnect multiple preserves. Anderson's analysis indicates that very large blocks of continuous forest are critical for preserving forest biodiversity at the landscape scale, and he provides a straightforward method to estimate the habitat area and conditions needed to protect biological diversity in any forested region.

Environmental lobbyist and attorney April Gromnicki uses the Everglades in Florida, USA, as an example of the political and managerial complexities that arise

when attempts are made to restore and repair a huge, badly damaged ecosystem. Restoration in the Everglades represents an unprecedented partnership between the federal government and a state. There are also many counties, regional planning councils, and a number of Indian tribes with jurisdiction over some of the area. Add to these the multiple government agencies with interest and responsibility in the Everglades – 14 federal entities alone – and the myriad non-governmental stakeholders, and one begins to think that it is amazing that anything has actually been accomplished. Gromnicki details the history and process that began in the early 1990s and brought together so many interested entities and individuals in an effort to correct the extensive damage done by government-sponsored drainage and flood control projects since the late 1940s. The actual, on-the-ground restoration work has only recently begun but, if fully implemented, the Everglades restoration project will surely serve as a model for large ecosystem restoration worldwide.

Part III. The Need for Global Efforts to Save Biological Diversity

Ecologists David Foster and William Labich make the transition to the international section of this book with an example of how a regional forest preservation scheme has the potential for not only becoming a model for saving biological diversity worldwide but also, through carbon sequestration, can help reduce global warming. They begin Chapter 12 by summarizing the history of the eastern North American forests that began to grow back about 150 years ago after two hundred years of cutting and agriculture. These forestlands now provide a second (and final) opportunity for their "natural infrastructure" to be preserved. The authors argue that these systems are actually global infrastructure, since the rapidly growing forests are actively accumulating carbon. Utilizing some of the ideas developed in Chapter 10 regarding the preservation of matrix forests surrounded by buffer lands, their "Wildlands and Woodlands" proposal for Massachusetts, USA calls for adding to currently preserved land until one-half of all land area in the Commonwealth is in permanent forest cover. Wildland, or protected natural area, would comprise 10 % of the total forest. The remainder, Woodland, would be actively managed for wood products and other resources. They go on to detail a practical approach for accomplishing these goals.

Brazil's biodiversity treasures and troubles are well known to conservationists. In Chapter 13 political scientists Kathryn Hochstetler and Margaret Keck describe policies and strategies that aim to deal with both environmental and social problems, which are often inextricably linked. One approach is a network of protected areas of two general types, one uninhabited and the other with human populations within them. Extractive reserves, as well as indigenous reserves, allow small scale, traditional uses of the land that, at least ideally, are environmentally sustainable over the long term. Another promising development in Brazil is the increasingly active role of the judiciary, with the Ministerio Publico having authority to investigate and prosecute environmental infractions arising from both the government and the private entities. Their efforts have helped ensure more effective implementation of the country's environmental laws. Another effective environmental protection strategy has been the creation of transnational activist networks that partner with strong, locally

based, grassroots organizations. This combination of local and international pressure has proven effective in resisting some environmentally damaging government and private development initiatives.

The rapid increase in anthropogenically derived carbon dioxide in the atmosphere over the past two centuries, and the likely consequence of increased global temperatures, is a well-known scenario. In Chapter 14 William Burns explores a different and less well-understood result of increased CO_2 levels, the acidification of our planet's oceans. Increased acidity may well prove a much greater threat to marine biodiversity than climbing ocean temperatures. Calcifying organisms such as coral will be particularly impacted, as will the reefs they create. If the pH of ocean water drops as much as some scientists predict, coral reefs and the highly diverse ecosystems they support will be in danger of collapse. Even greater amounts of calcium carbonate are precipitated by planktonic organisms, and population crashes of such plankton would result in massive disruptions of marine ecosystems and the human socio-economic systems that depend on them. Crabs, mussels, oysters, sea urchins and any other calcifying organisms will also be adversely affected. Research into the consequences of ocean acidification is young and poorly funded. Burns concludes with recommendations on research agendas and with a brief discussion of international environmental policy.

In Chapter 15 environmental strategist Jonathan Hoekstra provides a broad perspective on biodiversity conservation on the global stage. Using the adage "think globally, act locally," he discusses how twenty-first century consumers are linked to people and resources throughout the world. Citizens of the wealthier countries are clearly having ever increasing impacts farther and farther from home. A leader in The Nature Conservancy's global habitat initiatives, he goes on to examine the disconnect between the world's most imperiled biomes and ecoregions, and the actual places that have been preserved. His map of "crisis ecoregions" (Figure 15.2) provides a fresh perspective and should be a useful tool for directing future conservation efforts to places experiencing extensive habitat loss coupled with insufficient habitat protection. Next, he theorizes about ways that rapidly expanding access to communications and information technologies could revolutionize global conservation. He concludes with thoughts on the need for bringing the valuation of ecosystem services into the economic mainstream.

Our final chapter is by landscape ecologist and biology professor Robert Askins, who uses the story of a Japanese program to restore the Oriental White Stork as an analogy for some of the lessons in this book. Efforts initiated to recover a single endangered species inevitably lead to the need for preservation or restoration of appropriate habitat. Single, "flagship" species can become conservation icons, as did the Spotted Owl in the United States and the stork in Japan, focusing public attention on the importance of preserving biodiversity and fragile habitats. Educational programs, and the "umbrella effect" whereby an endangered species provides protection for the many organisms that share its habitats, are valuable spin-offs from the focus on one species. But conservation must operate at all geographic and ecological scales to be effective. Global environmental changes that affect biological diversity, like climatic warming and acidification of the oceans, require concerted international cooperation in the political and economic realms that is difficult to achieve. Perhaps because individual, attractive species are easier for people to focus their attention on, it is inevitable that many efforts begin there.

If we are to save biological diversity, there is clearly much work to do at many levels, and plenty of room for those with varied interests, training and skills to join in. It is our hope that the interdisciplinary nature of this book will stimulate new connections and ideas in the minds of those already working to preserve biological diversity. Better yet, pass this book on to someone not yet fully engaged in this struggle with the idea that one of the chapters will resonate with their passions and induce them join the effort.

Part I
Protecting Populations of Particular Species

Chapter 2
Toward a Policy-Relevant Definition of Biodiversity[1]

Bryan G. Norton

Abstract Defining "Biodiversity" can be a challenge because the term functions in two arenas—scientific biology and conservation policy. First, it will be noted that there are arguments that apparently show that the term is not rigorously definable in a way that makes biodiversity an additive quantity; the consequences of this undefinability for policy will be discussed. Second, it will be argued that it is more important to develop a policy-relevant definition, a definition that reflects social value as well as scientific soundness in characterizing biodiversity, and which functions to allow communication about what to do. What is important is to have a definition that encourages shared actions and allows for the improvement of our linguistic tools. Perhaps it will be necessary to develop the concept of "biodiversity" as a scientific concept, while pairing it with a more readily understandable phrase, such as "the web of life" for use in public discussions.

The Endangered Species Act of 1973 (ESA) was a bold departure in environmental legislation; it has become perhaps the most powerful environmental statute in the United States, and it has been employed both as a weapon—to stop threatening projects—and as a tool—to bring opposed interests to a bargaining table. Commentators have noted that species endangerment is only one aspect of the biological impoverishment of the world's ecosystems; some have suggested that references to "species" in the legislation (which includes species, subspecies, and distinct population segments of vertebrates) should be viewed as a surrogate for protecting living things and the natural systems in which they are embedded.

This chapter examines these broader concerns. To do so, I focus on the term "biological diversity," or "biodiversity," which has come to function as a label for the broad concerns for nature, its life forms, and its processes. I address two questions:

1. How should we *define* the term "biodiversity?"
2. How should we *characterize* and *measure* the *value* of biodiversity?

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