# Introduction to *Ecosystem Management and Sustainability*

Ecosystem management for sustainability in the broadest, ecological sense is a concept that expresses a simple outcome—the complete preservation of nonrenewable, natural resources from one generation to the next. Fundamental to this quest for sustainable ecosystems, as we know them today, is the preservation of biological diversity. Ecologically, the preservation of natural ecosystems and their component species is based on theoretical and empirical studies evaluating ecosystem stability, including resistance to change, and recovery and resilience, both of which are important components of sustainability. As many of the contributions to this volume demonstrate, the loss (or removal) of one seemingly inconsequential species has led to devastating ecosystem impacts and the collapse of whole populations and communities of organisms in many different habitats found worldwide. In the twenty-first century, scientists have now identified and measured overwhelming evidence for anthropogenic (human-caused) perturbations of our Earth's ecosystem, the biosphere. Carbon dioxide and other greenhouse gases have led to an increase in global temperatures with a rate of change unmatched in geological timeframes. Moreover, there are frightening scenarios for future large-scale changes in the Earth's landscape that could have devastating impacts on humankind. Sea level rise and increases in extreme episodic events are two impacts predicted for the future (IPCC 2007). Yet little is currently known about the specific changes in ecosystem properties and services that will unfold in this portentous future.

## Maintaining Species Diversity

Understanding how to maintain species diversity—a component of which involves the capability for species to recover following both natural and anthropogenic disturbance of minor to cataclysmic portions—is the foundation of ecosystem sustainability. (These ecosystem properties are active areas of research today, and many of them are presented as separate topics in this volume.) But even this simple definition of sustainability requires clarification because virtually every natural resource, including biological species, could be considered renewable, or replaceable, over a long enough timeframe. According to the fossil record, ecosystems today have survived major, mass extinctions through the evolution of new species: in fact, well over 90 percent of all species formerly on this Earth are now extinct. Seemingly irreversible extinctions of a biological species may become reversible in some sense if one considers today's advances in technology for cloning and amplifying genes. Moreover, those within some circles of societies around the world argue that problems related to the sustainability of our biosphere will be taken care of, ultimately, by the actions of a supreme deity, or by as-yet-unknown technological advances. Following that premise, environmental problems such as global change or high species extinction rates might seem less pressing to individuals, especially when overwhelming economic problems require their immediate attention.

If an individual, community, or organization is *not* extinguishing nonrenewable resources (including biological species) from the biosphere, or if our management practices are not building toward a future of unforeseen, negative events, a sustainable status (again, by definition), has been achieved. Yet sustainability in other arenas of society can be interpreted quite differently. For example, sustainable economics or commercial development can take on a new dimension when considered in the context of sustaining an acceptable standard of living for a particular society. Consuming only renewable resources, and only at a rate that will not diminish the current pool of a renewable resource, is one obvious solution to this problem. But because many resources used in common practice by humankind are far from being sustainable, this presents a monumental challenge for most societies across the globe, especially for those economies and standards of living that are deeply dependent on resources harvested excessively from the environment. Unfortunately, societies today with the greatest capabilities for accessing natural resources are also the ones with the highest standard of living and greatest usage. How will sustainability components such as biodiversity be accomplished on a global scale, including all societies regardless of their standard of living? This fundamental question facing the global community today can only be answered as an orchestrated effort directing a multidisciplinary, integrated approach that will span virtually all fields of study, including the "hard" sciences, the humanities, business, and law. Within this network, research methods and accompanying, specific measurements need to be identified, and then standardized, as the most accurate indicators of the quantitative degree of sustainability. Examples of this could include hidden costs of pollution, depreciation, ultimate depletion of natural resources, overproduction, negative alterations in esthetic value, or effects on health care expenses, just to name a few. Any quantitative index employed to quantify sustainability success will thus have to include a wide array of variables that are intertwined in a complex network of feedback and feed-forward interactions (see Volume 6, *Measurements, Indicators, and Research Methods for Sustainability*). In fact, these interactions may be the most difficult to understand. All of these multidisciplinary fields of study must be called upon to provide for the future, successful management of ecosystems necessary to prevent potentially serious consequences for our own species.

Effectively, with the current existence of global change issues such as elevated carbon dioxide in the atmosphere and warming temperatures, there are no habitats on Earth where anthropogenic disturbance is absent; that is, purely natural ecosystems (i.e., pristine areas, using the word in its purest sense) no longer exist. Many so-called official wilderness areas are in essence legislative constructs, built or restored habitats in which government mandates must approve attempts to restrict species or reinstate species. We now have to understand and manage already impacted ecosystems that were being managed previously from a simpler preservation approach. That is not to say that protection of critical areas will not be important for addressing the serious anthropogenic impacts already underway. For example, new management strategies for sustainability should now involve ideas for lowering global atmospheric carbon dioxide content and greenhouse gases that generate global warming. Encouraging plantation development for biofuels or as sinks for carbon dioxide absorption from the atmosphere are examples of ecosystem management techniques that are perceived to benefit the global community. But is this temptation to manage ecosystems to rectify anthropogenic impacts a sound strategy considering the complexities and difficult challenges of ecosystem management? Instead, is it not wiser to understand more comprehensively the potential harm of these impacts and act to eliminate pollution-point sources altogether? The same can be asked about the excessive harvesting that has led to serious declines and extinctions of species, plus community/ecosystem collapse. Just like common promulgations from the health sciences field, prevention is much less taxing and expensive compared to recovery and restoration. Species reintroduction, especially of those species high in the food web, is an active area of research and a current example of efforts at ecosystem sustainability. This approach is still very much in the experimental phase and, unfortunately, has evolved in response to major disturbances caused primarily by human alteration of the landscape and resulting pollution. *Ecosystem Management and Sustainability* contains articles covering all of these topics in greater detail.

## Predictions and Forecasts

In the ecological sciences, in general, the capability for prediction (forecasting) has been a goal for over a century. Yet progress has been slow at best. For ecosystem management to become a legitimate "hard" science, predictability and forecasting future changes in ecosystems is a prerequisite. Science areas such as chemistry, physics, and math have played a vital role in predicting all sorts of events that are driven by physical/chemical forces. These predictions involve very rapid reactions that occur over a fraction of a second to much more lengthy astronomical time scales that predict the motion of planets and solar systems over millennia and well beyond.

The impact of perturbations due to anthropogenic forcings such as climate change have elicited a sense of urgency among ecosystem managers at all spatial scales, and the field actively pursues this capability to predict and forecast. Legislators want to know how much and how fast ecosystems will be influenced, either negatively or positively, as the result of global change. Ecological forecasting is problematic, however, because so many variables are involved at differing degrees of influence, and myriad feedforward and feedback interactions could as well play prominent roles. Even most physical scientists admit that biological systems from the cell level to the landscape incorporate an almost overwhelming matrix of variables. This complexity impedes the capability for predicting the future and, it follows, efficacious management strategies for sustainability. Today's technological advances, however, especially computer capabilities for data storage and rapid processing, should make the most complex systems understandable and predictable in the future. Acquiring this capability is the ultimate goal for ecosystem managers.

The encyclopedic approach taken with this volume and the other nine volumes of *the Berkshire Encyclopedia of Sustainability* provides a venue for communication between experts in the field and nonexperts, which in turn allows the latter to better appreciate the serious challenges ahead for humankind, especially if plans for the future lack a sustainability objective. After all, if only experts are convinced of the value of sustainable ecosystems, an electorate will rarely vote into office politicians who are knowledgeable about and supportive of ecosystem management principles. In this volume, numerous experts in their respective fields examine basic principles of ecology and ecosystem management. Aside from these fundamental ideas, their articles cover important topics that address specific issues of ecosystem management related to pollution impacts, agriculture, hunting and fishing, forestry, water, indigenous people, the esthetic value of natural resources, shale gas extraction, tree planting, and rain gardens. Because climate change is projected to bring greater episodic extremes, such as floods, minimum and maximum temperatures, droughts, and so forth, one article is dedicated entirely to this topic.

## Politics and Ecosystem Management

The volume also addresses the growing field of environmental law because much of our future may involve litigation and court challenges to federal and state attempts at regulating anthropogenic pollution and the protection of endangered species. (In his bestselling book *Storms of My Grandchildren,* James E. Hansen [2009] offers an interesting look at a case history describing the interaction of science and politics, in particular dealing with the problem of greenhouse gases in the atmosphere and global warming.) Many experts in ecosystem management believe that the political arena is a crucial target for the ultimate success of ecosystem management in the United States and elsewhere around the world, and that economic interests instead of the science of sustainability often drive political decisions about ecosystem management. For example, politicians in the United States are elected and re-elected based upon their membership in and financial support from two major parties, both of which raise huge sums to back their candidates, especially those at the highest levels of government. In many cases the major contributors to these parties are (or represent) industrial corporations that are responsible for the pollution driving global change. This realization and the social paradox generated are related to the critical regulatory role of governments discussed in several of the articles in this volume. For instance, in "Administrative Law," Bruce Pardy of Queen's University, Canada, explains how in Western legal systems with a constitutional separation of powers, government officials carrying out and enforcing ecosystem management directives must operate within the bounds of a statutory mandate (i.e., authorizing legislation). This process ensures the protection of individual rights and will reassure ordinary citizens who see ecosystem management as coercive, just another case of government telling them what they can and cannot do, that checks and balances are in place.

Politicians are the ones who must legislate the rules driving strategic ecosystem management, a crucial ingredient for installing sustainability ideas into a society that can perpetuate the process only by electing the regulatory officials. But, as many articles in this volume attest, individual action, as well as interaction between public and private sectors, are powerful catalysts to bring about change.

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## Suggested Reading

Hansen, James E. (2009). *Storms of my grandchildren: The truth about the coming climate change catastrophe and our last chance to save humanity.* New York: Bloomsbury.

IPCC (Intergovernmental Panel on Climate Change). (2007). Climate Change 20: The Physical Science Basis Report. Cambridge University Report. IPCC: London.

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