The transformation of Earth’s habitats and ecosystems, along with an inevitable loss of biological diversity, involves a complicated set of social, economic, and political issues. Whereas most public discourse describes the problem from a first-world perspective of the loss of endearing species or the wanton destruction of natural beauty, the real story of biodiversity loss is a complex melange of mind-numbing concerns such as economic inequalities and pernicious incentives, poverty, agricultural policies and food security, political justice, and many other societal manifestations of the way in which people relate to the land and the resources it houses.

What this implies is that the guaranteed way of keeping the status quo—of ensuring that habitats and ecosystems will continue to degrade and that species loss will continue unabated—is to keep visualizing the problem from an overly simplified, developed-world perspective. Yet because the problem is so vast, the causal interconnections and consequences so complex and often indeterminate (at least before the fact), it is often easy for people to deny there is a problem or to claim it is intractable and thus fail to act. Those having a vested interest in maintaining the status quo, particularly many policymakers, are loath to look beyond the economic and political here-and-now and take a more global, long-term perspective. That stance is made easier by scientific knowledge that appears, or is made to appear, indeterminate and conflicting—for example, whether there is global warming—or by uncertainties in the societal consequences of scientific knowledge, even when there is general consensus about the latter.

The scholars in this volume share a common view: despite scientific uncertainties about Earth’s biological diversity and its rate of loss, what we do know is that species loss is accelerating at an alarming rate; despite uncertainties about the details of the long-term societal impact of this loss, those impacts have been and will continue to be profound; finally, despite the certainties about how humans
have adversely interacted with Earth’s biosphere and what current trends portend for the future, policy responses remain inadequate. As a consequence, societies everywhere will be at increasing risk if current trends continue.

This book does not pretend to provide insight into all the disciplines and nuances of biodiversity science, nor does it explore all the conservation and policy implications of the biodiversity crisis. Some important topics are missing, in several cases because promised contributions to this volume did not materialize; also, from the outset it was recognized that it is impossible to cover all aspects of biodiversity science and policy in a single compendium. Thus important topics such as the benefits of biodiversity, including ecosystem services, marine biodiversity, and a comprehensive summary of the factors leading to the loss of biodiversity, are not covered here, but detailed treatments of them can be found in many publications (Norse 1993; National Research Council 1995; Heywood 1995; Daily 1997). The task here is different. The last decade in particular has seen a steadily growing literature on the biodiversity crisis. Much of that literature finds its home within the academic community, but an increasing component is in the public domain. Few volumes attempt to have a foot in both communities, and the chapters included here have been chosen to bridge that gap in a way not found in similar efforts. The first section contains six scientific viewpoints that ask what we really know about the magnitude of biodiversity and extinction, how we might improve our knowledge, and what this information says is happening to Earth’s species. The second section contains a series of chapters and perspectives that attempt to construct a framework for seeing biodiversity loss within a societal context and predicting what it means for the future of societies. The third section takes up some of the policy implications of biodiversity loss, primarily at an international level and especially through the Convention on Biological Diversity, and introduces the dialogue that must take place between scientists and policymakers. Then, in a short final section, that dialogue takes center stage in two chapters that explore how scientific knowledge and uncertainties about the loss of biological diversity and its consequences are not eliciting adequate responses by policy-making institutions.

THE SCIENCE OF DIVERSITY AND EXTINCTION

What are the undeniable scientific conclusions we can state about diversity and extinction? There are many, of course, but three have implications above all others. The first circumscribes our knowledge about the abundance of the natural world: we know that about 1.75 million species have been discovered and described (Heywood 1995) but that many millions remain unknown to science. The second undeniable conclusion has two parts and constitutes the evidence of our misuse of the natural world and of its slipping away: we know that, for at least the last five centuries the global rate of species extinction has been far higher than the geological background rate and that this spike in extinction is caused by human ac-
tivities (Lawton and May 1995). Moreover, we know that the rate of local extirpation of species—the first signal that local habitats and ecosystems are functionally unraveling—is accelerating rapidly, essentially at an immeasurable pace. Finally, the third undeniable scientific conclusion is that the functional integrity of habitats and ecosystems is unraveling across the globe as local extinction tears apart the building blocks of the ecological nexus that provides the ecosystem services supporting all human endeavors (Heywood 1995; Daily 1997).

These facts are the foundation of the biodiversity crisis. They are not the only things we know. Indeed, we need to know much more. How many species make up Earth’s ecosystems? Nigel Stork (chapter 1) considers this question, one of the more controversial in the scientific study of biodiversity. Estimates run from 4 or 5 million to over 100 million. Most opinion settles in the range of 15 to 60 million, and in these discussions the answer one arrives at depends on how insect numbers are estimated. Stork settles on a “working figure” of a little more than 13 million species, with 8 million being insects. Others believe that Earth’s habitats and ecosystems may harbor another 30 million species of insects. The debate will not be settled until more precise methods and more extensive studies are undertaken to sample the world’s biota. One suggestion by Norman Platnick (chapter 2) is to concentrate on a sampling regime for some of the “megadiverse” groups, especially those with a worldwide or nearly worldwide distribution. He argues that in so doing we will come to have a broader understanding of global patterns of diversity than if we just focused our attention on a few localities around the globe.

For many people it may not be important how many species there actually are, yet such a view overlooks the benefits that currently known biological diversity provides societies everywhere. If at most 5 to 10 percent of the world’s species yield the benefits we now enjoy—food, fiber, trade, medicines, industrial products—it is not difficult to imagine what knowledge of the other 90 percent (or 99 percent if the global species number is many tens of millions) could mean for future generations. In addition to these economic benefits, the more we understand about species diversity, the more we understand about the structure and function of ecosystems. Such knowledge is the linchpin of maintaining and efficiently managing the ecological services provided by the various habitats and ecosystems.

Without a clear understanding of how many species there are, we cannot come to grips with extinction. The question of concern to everyone, of course, is how quickly species are being driven to extinction. Given a certain regime of habitat fragmentation or landscape disturbance, how many species are likely to be driven to extinction, locally or globally, in the short term or in the long term? Such questions cannot be answered satisfactorily without a better estimate of species numbers.

Both Stork (chapter 1) and Ross MacPhee and Clare Flemming (chapter 4) examine our knowledge of extinction rates, but from two different perspectives. Stork reviews the various approaches used to estimate global extinction rates, all of which, despite their differences and margin of error, show that a catastrophe is at hand. MacPhee and Flemming, on the other hand, take a single “well-known”
group—mammals—and in the most comprehensive analysis of how-do-we-know-what-we-think-we-know about extinction, they demonstrate that getting the science right when counting extinction events is often not straightforward and that efforts to put together lists of extinctions are fraught with difficulties.

This is not to say such lists are not informative. Indeed, the general finding of such exercises is that we have lost innumerable species through human activities. The real focus, however, should be on the loss of habitats and ecosystems; at the rate these have been lost over the last 100 years, it may be academic whether this species or that species is or is not extinct. Melanie Stiassny (chapter 3) argues that because freshwater ecosystems are particularly vulnerable and disappearing at a rapid rate from increasing human demand for freshwater and from pollution, fully 25 percent of global vertebrate diversity, in the form of freshwater fish, is at risk of extinction. She points out that as ecosystems such as freshwater environments are progressively fragmented and become habitat islands, an increase in extinction rate is inevitable.

The commentaries by Diana H. Wall and G. Carleton Ray pick up a thread running throughout all these chapters: despite many years of scientific research we still know so little about the natural world that precise statements about diversity and its distribution and loss are difficult to make, especially in the developing, species-rich nations of the world. This is especially true, as they point out, for all the poorly known habitats and ecosystems—including soils, the deep sea, most freshwater ecosystems, forest canopies, and many more. Thus we may have accumulated a substantial body of knowledge in the biodiversity sciences, but if we are to understand what is happening to Earth’s diversity and how to manage it more intelligently and cost-effectively, we need to know much more and we need to see beyond the obvious and seek out the groups and habitats that are poorly known.

THE EXTINCTION CRISIS AND THE FUTURE OF SOCIETIES

If the loss of biodiversity had no measurable effect on the well-being of human populations, then aside from the aesthetic or ethical values we see in biodiversity there might not be great cause for alarm. But the fact that the international community, national governments, nongovernment organizations, and countless millions of people are alarmed manifests the undeniable conclusion that biodiversity does matter. And obviously it does. The benefits have been enumerated by many.

Yet more often than not, discussions about the linkage between biodiversity loss and societal well-being focus on the ways in which humans are causing the destruction of biological diversity, and much too little attention is being paid to the consequences of biodiversity loss. Common sense leads one to conclude that those consequences are and will be profound. If 70 or 80 percent of the world’s people depend on the direct appropriation of diversity to meet their daily needs—food, medicines, firewood for cooking, shelter, and trade and commerce—then the loss
of diversity means that over time societies will become increasingly disrupted. The fact that more and more wildlands are being converted to human uses, and then those same lands are being abandoned at an ever-increasing rate, is evidence that the land as currently managed is increasingly unable to meet human needs.

It is clear that the loss and disruption of local ecosystems can have direct adverse effects on people's livelihoods. There are many examples of this dysfunctional relationship at a local level. Loss of arable land and loss of sources of firewood are two. But what about at national and regional levels? As biodiversity continues to diminish, what will be the consequences for nations as a whole? There is surprisingly little analysis of this question. The chapters in the second section provide various perspectives.

Joel Cracraft (chapter 5) looks at a large series of indicators of species diversity, threats to diversity, and the capacity to respond to those threats for 77 developing countries. About a third of these countries, most of which are in Africa, have moderate to high threat to their biodiversity but at the same time have low capacity (economic, educational, scientific) to address those threats. The obvious conclusion is that some countries and regions are likely to feel the consequences of biodiversity loss sooner than others. But what might these effects be and what are the implications for their neighbors?

The most obvious effect is on the capacity of a country or region to feed itself. In various areas of the world, particularly parts of Africa, the population growth rate exceeds the rate of growth in food production, a fact that has many implications for national and regional security. John Burnett (chapter 6) reviews the historical and ongoing story of biodiversity loss from expanding agriculture, which carries with it the loss of soils and increased need for a dwindling supply of freshwater. He also raises the specter of the loss of genetic variability accompanying the rise of high-yield cultivated varieties. Although these domesticates have increased food production, they carry with them many environmental costs and social impacts and they place constraints on the future adaptability of our food crops to environmental change. As Burnett notes, the loss of wild genetic diversity in food plants has many implications for the future of sustainable agriculture. Much the same theme underlies David Pimentel's perspective in this section. He also raises other linkages between biodiversity loss and the future of agriculture, namely that without wild biodiversity the difficulties for realizing sustainable agriculture or forestry are enormous because of the loss of natural biological pest control, pollinators, and agents of nitrogen fixation.

Functioning societies need food security. They also need health security, and that depends on the maintenance of wild biodiversity, as discussed by Francesca Grifo and Eric Chivian (chapter 7). The derivation of most of our critical pharmaceuticals is to be found in wild biodiversity and the indigenous knowledge that has developed about those species. Modern medicine has spread throughout the world, yet it is clear that this form of medicine is economically inaccessible to most of the world's people, who still rely on traditional medicines for most of their daily
health needs. For many people, their pharmacy is in the local forest or wildlands. It does not take much imagination to see that if this pharmacy is lost, the level of health for people dependent on medicinals from these areas will suffer, with all the societal costs that entails. Intergovernment and government health agencies see world health primarily in terms of the spread of modern developed-world medicine, yet much more research must be undertaken that investigates the consequences of the loss of traditional medicines on national and regional health security in many areas of the world.

If the loss of biodiversity has an adverse influence on a country's food supply or level of health, then it can be said to have an effect on the country's internal security. Arthur Westing (chapter 8) goes further and notes that using resources in an unsustainable manner, though perhaps contributing to national wealth in the short term, eventually erodes national security in the long term. He argues that it is extremely difficult to establish a direct causal link between environmental degradation and human conflict in any particular instance, but as he notes, that may not be the point: if one sees a nation's security as being dependent on the well-being of its citizenry, then the loss of biodiversity will have an obvious linkage to long-term security. It is clear that much more research and analysis are needed to develop a better understanding of environmental degradation and its role in shaping national and regional security issues.

Losing (converting) biodiversity may appear to generate wealth over the short term, but it is a complex issue to determine whether that gain is offset by short- and long-term costs because many values can be assigned to intact habitats and ecosystems. In recent decades the field of ecological or environmental economics has burgeoned, and Dominic Moran and David Pearce (chapter 9) guide us through some of the complexities. The use of biodiversity improves human welfare and thus has an economic value, but biodiversity also has intrinsic values that cannot be assigned a cost. "Getting the price right" on biodiversity is crucial for intelligent management and use, but Moran and Pearce raise a little-appreciated issue: because our scientific knowledge of biodiversity is limited, this uncertainty constrains the accuracy of any economic values we might want to place on it. Therefore, they stress, improved scientific understanding of biodiversity is crucial. In the meantime, prudence dictates the application of the precautionary principle to how we value our biological resources.

GETTING SOMEONE TO LISTEN: EFFECTING POLICY CHANGE

There are probably few, if any, environmentalists who think society is doing enough, that governments' policy responses are sufficient. By and large, policy-making institutions, whether local or even intergovernmental, respond to their constituencies. Unfortunately, the problem is that biological diversity does not have much of a political constituency. Nevertheless, everyone would probably
agree that some progress is being made—the Convention on Biological Diversity is a shining example, despite its difficulties of implementation.

The chapters in earlier sections of this volume circumscribe some of the reasons why having effective policies toward biological diversity meets so many roadblocks. First, there are large gaps in our knowledge of biological systems. It takes a sophisticated scientific understanding of a region to manage its biological diversity effectively, yet scientific knowledge is insufficient by itself; one must also integrate information about how those resources are being used, how people and biological diversity meld into a whole.

Second, the context for conserving biological diversity is interleaved with societal needs, thereby making the constituency for policy decisions about how biodiversity is to be managed large indeed, and often conflicting. As Norman Myers (chapter 10) remarks, we must expand the policy arena for biodiversity conservation because the older approaches—seeing protected areas, especially national parks, as the locus of conservation effort—are not getting the job done. Myers sees the problem precisely as policymakers should see it: “There is much complementarity between our policy responses to the biodiversity problem and our responses to other problems of the biosphere.” Save the world, you save biodiversity. Because of the linkages between biodiversity and societal well-being, policy responses must be broader than the current focus of many conservationists and governments.

As noted earlier, however, policymakers respond to their constituents, and people tend to be more concerned with other issues than with biodiversity loss. Why? Because they do not have the information they need to see biodiversity as an issue that is important to them. Thomas Lovejoy (chapter 11) makes this point when he argues we need to find a better way to get people to see the benefits provided by biodiversity. Self-interest is the great motivator; at present people do not see the conservation of biodiversity as a matter of self-interest. Nor do they understand what biodiversity loss might mean for their children. If they do not get these fundamental facts and see the implications of biodiversity loss for humanity, how can they be expected to call for policy change? Lovejoy makes a further point, echoed throughout the volume: lack of knowledge in the biological, economic, and social sciences is hindering our efforts to create sustainable societies through informed decision-making.

Perhaps the most fundamental change in the collective policy psyche of the world’s nations toward biological diversity is the Convention on Biological Diversity (CBD). Stripped of its droll legalese, it is to a large extent a manifesto to save the world and save biodiversity together. It reflects the linkages that Myers refers to. Mulongoy, Bragdon, and Ingrassia (chapter 12), who have worked within UNEP and the CBD Secretariat, lead us through the objectives of the convention. Their description of the convention demonstrates that it is a remarkable blueprint for progress, even leaving aside all the hedging and compromising language that international documents of this type are burdened with.
BRINGING TOGETHER SCIENCE AND POLICY

Policy instruments such as the CBD are constructed by politicians, who (we hope) are aware, or reflect government policy that is aware, of the realities of the biodiversity crisis and its complex linkages to society. Biodiversity loss, like the loss of global ozone, is first and foremost a knowledge issue. Biodiversity scientists, on the ground, have led the way in documenting the loss of diversity, its many ecological values, and the consequences of that loss. At the same time, the linkages between degrading environments and societal well-being have been explicated by other sciences. Scientists have been involved directly because policymakers attempting to deal with biodiversity loss would be hopelessly in the dark without the information provided by accurate science. Yet as Jeffrey McNeely (chapter 13) describes, science and policy are often at odds with one another. Policy change is usually designed to provide benefits to constituents, not constraints, and at least in the developed world these constituents gobble up the benefits that flow from biodiversity depletion. They cannot easily identify one or two obvious culprits causing the problem, and they do not see biodiversity loss as affecting them directly. Causally biodiversity loss is complex—in this way it is not at all like atmospheric ozone depletion—and therefore it does not lend itself to easy policy responses. However, scientists must learn to function within a policy environment and must become more involved.

Thus a meaningful policy framework for saving biodiversity depends on knowledge, and the preceding discussion stresses the role of science in improving management of biological resources. But knowledge can also be used to shift values, and all policy decisions are founded on a particular set of values. Peter Raven and Joel Cracraft (chapter 14) argue that our value systems in the developed world are out of step with any policies that might have lasting, positive influence on biodiversity. Citizens of developed nations generally misconstrue how the remainder of the world—the developing world—is operating. That world contains the vast majority of the world’s poor, undereducated, and sick, only about 6 percent of the world’s scientists, but probably 80 to 90 percent of its biodiversity. People in that world—the world of the poor—use biodiversity in fundamentally different ways, and at fundamentally different rates of consumption, than we do. Collectively, we do not appear to understand that difference or its implications for the future and do not seem terribly interested in formulating policy to address the situation. The results of science must be digested and interpreted within a broader setting, one that moves our value systems from those anchored squarely in maintaining or expanding our cultural hegemony over the economically disadvantaged to one that recognizes and accepts a shared destiny for the planet.

A haunting coda to these concerns, and to the book, is provided by Strachan Donnelly in his perspective. As a philosopher who sees himself as part of the public outside the scientific mainstream, he laments that scientists have largely failed to create a public informed on the issue of biodiversity loss: “In the main, the sci-
Scientific community has fed our economic and technological boosterism and left us bulls in the China shop of nature... The gauntlet of public education is thrown and ought not be ignored. Our citizen ignorance is an integral part of the living planet in crisis.”

REFERENCES