UCS Population-Environment Linkages Series, No. 4

HUMAN POPULATION AND THE FUTURE OF BIODIVERSITY

Union of Concerned Scientists

August 2000

Executive Summary

Current Trends in Biodiversity Loss

The Role of Population Growth

Population Growth in Highly Biologically Diverse Regions

Demographic Hope For Biodiversity

Messages for Policymakers and the Media

Sources

HUMAN POPULATION AND THE FUTURE OF BIODIVERSITY
An Information Update produced by the Union of Concerned Scientists
August 2000

The population of our species—which recently reached six billion—is ecologically unprecedented. Based upon mathematical relationships comparing animal body size to habitat area, human population is estimated to have reached over 30 times what would have been expected had agriculture not been adopted (Cincotta and Engelman 2000). We have entered an era where the extent of human numbers, per capita consumption, and technological prowess are measurably altering global biophysical and atmospheric processes.

While growth rates in many parts of the world are beginning to decline, world population continues to grow by more than 75 million people per year. According to the most recent United Nations projections, global population by 2050 is expected to range from a low of 7.3 to a high of 10.7 billion (United Nations 1998a).

While the human population has increased rapidly, recent research suggests that species extinctions during the past century have occurred up to 1,000 times more frequently than in pre-human eras. From projected habitat losses based on current trends, some biologists project that 2 – 13% of the world's species could go extinct in the period between 1990 and 2015 (Reid 1992). More could disappear as a result of other causes, such as invasions of exotic species and diseases, pollution, over-harvesting, and human-induced climate change.

Among global trends affecting biodiversity, arguably the most hopeful is the recent slowing of human population growth. This is to a large extent the product of changing ideals of family size and birth timing, higher educational attainment among girls, and improved access to family planning. Reaching an early peak in human numbers, a possibility within the next 40 years, would dramatically improve the prospects for saving wild species and the ecosystems in which they live and evolve.

CURRENT TRENDS IN BIODIVERSITY LOSS

Biodiversity, short for biological diversity, describes the variety of living organisms of all kinds—animals, plants, fungi, and microorganisms—that inhabit a particular area. Most commonly, biodiversity is measured by the number of species in an ecosystem.

However, diversity *within* a species—that is, the variety of genes found in a population—can be critical to the survival of that species. This *genetic* diversity, which is indicated by the subdivisions of species such as subspecies and populations, is the raw material for adaptation to environmental changes and for the evolution of new species in the future.

No species lives alone; all the members of a biological community are linked together in the web of life. They depend on each other for nutrients, water, energy, and other resources, forming *ecosystems*. At a larger scale, then, the diversity of different ecosystems across the landscape—forests, prairies, wetlands, and deserts—is also an important component of biodiversity. The largest ecosystem is that of the entire Planet Earth—the biosphere with its millions of kinds of living things.

Accounting for the annual economic productivity of the Earth's biodiversity—for example, the value of commercial fishing or timber production, or even of that of certain genes used in crops or pharmaceuticals—is a straightforward exercise. Much of biodiversity's services, however, never trade in the marketplace. Some—such as the generation of our atmosphere's oxygen, the purification of water, the pollination of crops, the formation of organic soil components, and the cycling of soil nutrients—are essential to human life and seemingly irreplaceable on a large scale. Another, even less tangible, category includes biodiversity's aesthetic contributions to the human experience, and its role as an essential ingredient in the quality of life.

Paleontologists estimate the background rate of species extinction—the long-term extinction rate exhibited prior to humanity's influence—at between 1 and 10 extinctions each decade among every million fossil species. Assuming from a variety of estimates that 10 million species are alive today (Stork 1993 and 1997, May 1988, Hammond 1992), scientists can expect from 1 to 10 species to go extinct each year from all forms of life, visible and microscopic. In fact, species are exiting much faster. Based on records of extinction among the best-studied types of animals, ecologist Stuart Pimm and colleagues calculated extinction rates during the past century to range from 100 to 10,000 species per year (again, assuming 10 million species exist). That rate is between 100 and 1000 times faster than the background rate of species extinction (Pimm et al 1995).

The roots of current extinctions actually go back 6,000 to 10,000 years, to a time when the habitats of human hunter-gatherers were going through a change. Pressured by the upward momentum of its own numbers and a related scarcity of game animals, *Homo sapiens* turned to domesticating plant and animal species, gradually took to farming and livestock raising, and forged a new relationship with Earth's ecosystems (Boserup 1965). Using fire and primitive tools, humans learned to purposefully shape the course of natural events, and then, slowly at first, to radically refashion entire ecosystems—to create what scientists now call "human-dominated ecosystems." Today these ecosystems appear as a highly varied set of landscapes, from swidden farming to dense metropolitan centers, each intended to meet the needs and designs of members of our own species, generally at the expense of the needs of wild species. In addition, our extraordinary mobility has facilitated the transport of exotic plants, animals, and diseases, transfiguring previously isolated ecosystems.

How far have these trends gone? Well over 70 percent of Earth's habitable terrestrial surface is fully or partially disturbed by agriculture, natural resource use, or construction (Hannah et al 1994). Humans now claim for their own use around 40 percent of each year's terrestrial net primary productivity—the total organic material produced by photosynthetic plants on land (Vitousek 1986). Nearly four-fifths of all native forests that covered our planet at the close of the last ice age has been covered, cleared, fragmented, modified, or degraded (Bryant et al 1997), and half of that cover has completely disappeared. At least 10 percent of the world's coral reefs are severely degraded. Another 30 percent are considered in a "critical state," and thus likely to be lost within the next two decades (Wilkinson 1993).

Unlike other natural resources, biodiversity is affected by both extensive means of acquiring food and shelter (farm expansion and suburban sprawl), and intensive means (intensive agriculture and urban concentration). Farm expansion and sprawl play an important role in the clearing of terrestrial and wetland habitat. At the same time, the intensive solutions to food and shelter needs tend to overload aquatic and marine ecosystems with pollutants.

Clearly the additions to human population projected for at least the next half-century will require further appropriation of the Earth's ecosystems. Such growth, coupled with expected growth of consumption and further globalization of trade and much-needed improvements in the living standards of the world's poor, is likely to put at further risk much of the world's remaining biodiversity.

THE ROLE OF POPULATION GROWTH

The most systematic reviews identify at least a half-dozen major underlying causes for current declines in species, wild breeding populations, and natural ecosystems. In each review, population growth—which can include global and local natural increase and migration—is listed as one of these primary root causes (Soule 1991; McNeely 1995; Stedman-Edwards 1997; WRI, IUCN, and UNEP 1992).

It is important to note, however, that none of these reviews suggest that the impacts of human activity on biodiversity are driven by population growth or population density alone. It is generally accepted that several underlying causes are at work, some applying pressures that can alter ecosystems and deplete species, the others undermining natural and social means that could limit or reverse those changes. Even in local case studies where researchers found the growth of nearby human populations to be the most apparent locus of biodiversity loss, these same authors consistently indicated that, on close analysis, a complex mix of interacting conditions and failed remedies were involved (Dompka 1996, Goriup 1998, Brechin et al 1994).

How important is population growth and density—the product of past growth—to current global biodiversity loss? There is no credible numeric answer to that question. A recent analysis that relied on several measures of root causes (including population density) to mathematically predict proportions of threatened species in over 107 countries was only partially successful (Forester and Machlis 1996, also see Noss and Cooperrider 1994).

Nor does the literature on individual species provide many clues to the linkage. Understandably, these studies have focused on the *direct causes* of decline in breeding populations—the effects of habitat disturbance, fragmentation, and loss; biological invasion; pollution; overhunting; and, in a few recent cases, climate change—rather than measures of human population. But there are a few exceptions. In a recent study, over half of the deaths of African wild dogs were associated with direct human contact and infectious diseases obtained from domestic dogs (Woodroffe and Ginsburg 1999). Similar relationships could explain wild carnivore declines worldwide. And recent research indicates that above a human population threshold, usually between 15 to 20 people per square kilometer, elephants move out of certain parts of Zimbabwe. The authors suggest that this threshold may represent the patterns of farming and natural resource use that result from this population density, rather than the elephants' aversion to human numbers *per se* (Hoare and Du Toit 1999, Parker and Graham 1989).

Lack of hard evidence for the linkage has not deterred scientists from drawing conclusions based on fundamental ecological theories. Many biologists believe that continued rapid population growth in

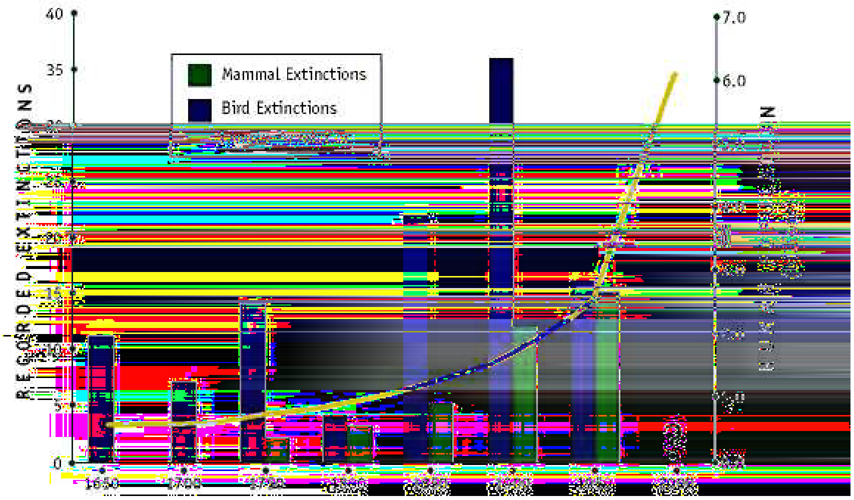

Figure 1: Trends in Extinction

Though by no means a simple cause and effect relationship, recent analyses conclude that population growth is among a handful of underlying causes of biodiversity loss. In the bar graph, bird and mammal extinctions were summed up for 50 year periods. The year appearing on the bottom axis ins the mid-point for that period.

Source: Data from WCMC, 1992; adapted from graphs by Goudie, 1986.

the tropics is undermining the integrity of biodiversity-rich ecosystems, and that present demographic trends bear strongly upon what biodiversity will look like in the future (Myers 1994, Wilson 1992, Ehrlich and Ehrlich 1981, Raven 1990). But population stabilization alone would not be sufficient to return extinction rates to background levels.

There is clear evidence connecting human population growth to many of the direct causes of biodiversity loss, including habitat loss and fragmentation, biological invasion, pollution, overharvesting, and human-induced climate change. Just as clearly, population is not the sole culprit, nor do pressures from population growth, density, or migration work alone. Put simply, human-induced biodiversity loss can neither be fully understood nor can it be resolved, in practice, from this perspective alone. Yet, in the presence of population growth, the notion of sustainability is, as biologist Edward O. Wilson puts it, "but a fragile theoretical construct." (Wilson 1992).

POPULATION GROWTH IN HIGHLY BIOLOGICALLY DIVERSE REGIONS

In many parts of the world, recent human population growth and migration into species-rich regions pose mounting challenges to conservation efforts. In a recent analysis, Population Action International (PAI) examined demographic trends in some of the world's most threatened species-rich terrestrial regions. For their analysis, PAI utilized data from the 25 *global biodiversity hotspots*, a conservation priority system developed by ecologist Norman Myers, Russell Mittermeier, and scientists at Conservation International. The biodiversity hotspots are regions that feature exceptional concentrations of endemic species (each hotspot contains at least 0.5% of the world's plant species as endemics) while experiencing exceptional loss of habitat (at least 70% of each hotspot's primary vegetation has been lost). Within the hotspot boundaries may live at least half of the world's terrestrial species. Recent human population growth and migration into these species-rich regions have made biological conservation efforts more urgent, more difficult to conduct, and often more likely to conflict with human needs.

Based on data compiled by Population Action International, as of 1995, more than 1.1 billion people were living in the global biodiversity hotspots. While hotspot boundaries enclose some 12 percent of the planet's land surface, these species-rich regions were then home to about 20 percent of the world's human population. All but one of the 25 hotspots are still experiencing net population growth. 19 of the 25 hotspots are growing faster than the world's population as a whole, at 1.3 percent.

By 1995, an additional 75 million people were already living within the three *major tropical wilderness areas*, the most pristine and least fragmented of all species-rich regions of the world. An estimated 75 percent or more of the naturally vegetated habitat remains in each of these areas (Mittermeier et al 1998). Population growth in these regions has been proceeding at two and a half times the rate of the world's population as a whole. If present deforestation rates continue unabated, these vast native forests could be reduced to a handful of isolated woodlands in the coming decades.

Whatever strategies ultimately emerge, geographical patterns of human population density, growth, and migration will continue to influence decisions in global biodiversity conservation (Soule 1991, Wikramanayake in press). Future demographic patterns, however, are themselves uncertain. To some extent local population density and migration, particularly as they operate by the middle of the 21st century, will be influenced by how quickly effective, voluntary family planning programs are extended to couples in the biodiversity-rich tropics.

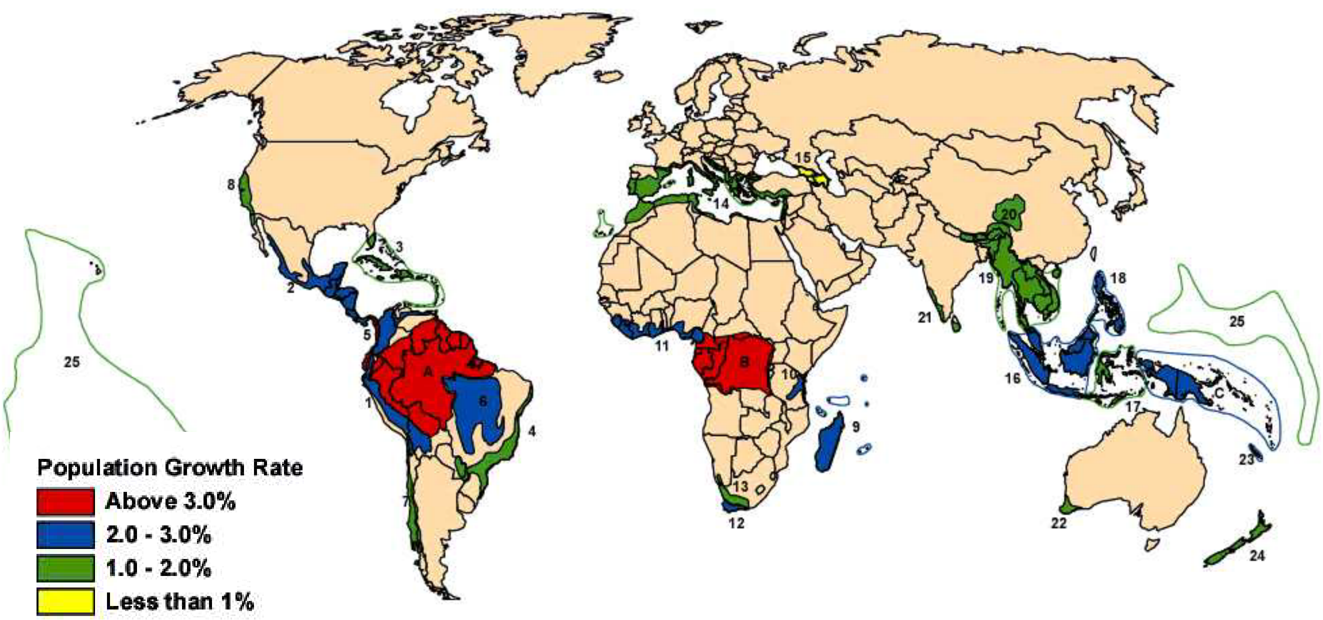

Figure 2: Population Growth in the Biodiversity Hotspots

The map shows population growth rates in the biodiversity hotspots (1-25) and the major tropical wilderness areas (A, B, & C). To qualify as a hotspot, a region must be home to an extremely high number of endemic species of vascular plants, such as grasses, flowering plants, trees, and ferns. As a second criterion, hotspots have lost 70 percent or more of their original primary vegetation intact. In contrast, the major tropical wilderness areas are the least disturbed among species-rich regions, and encompass the last remaining tracts of intact tropical forest.

Map courtesy of Population Action International.

DEMOGRAPHIC HOPE FOR BIODIVERSITY

According to the most recent long-range population projections, by 2100 today's human population of six billion could reach as high as 16 billion. Alternatively, it could peak at less than 7.5 billion around 2040 and return again to below 5.5 billion by the century's end (United Nations 1998b) (see Figure 3). Between these two extreme projections lies a vast array of possible futures, including everything from continued exponential growth to early stabilization and even eventual decline. The outcome of this range of possible population trajectories, now uncertain, could make a critical difference to the prospects for conserving the remainder of our biological diversity in the coming century and beyond.

The past 30 years have seen enormous progress toward providing universal access to family planning services, as called for in the Cairo *Programme of Action*. There is still a long distance to go. More than 100 million married women would like to space and limit childbirth but lack access to the means to accomplish these goals (Alan Guttmacher Institute 1999).

Fertility rates are not descending "on their own," in apparently spontaneous response to economic change. The investment and hard work of governments—those of developing countries as well as industrialized donor nations—and non-governmental organizations have made a difference. Studies of Southeast Asian nations suggest that today's declining population growth rates resulted in large part from policies and programs supported decades earlier. Voluntary family planning programs were key. But so were other policies that increased the demand for these programs—especially policies that put more girls into classrooms, and opened employment opportunities for women (Tsui 1996, Bongaarts 1998).

The future could see a continuation of today's impressive decline in fertility—if citizens and the governments that represent them support and fund the policies and programs that make such change possible. Decisions made today will have an enormous influence on the future size of world population. No one can accurately predict how much of a difference a stabilized or even temporarily declining world population will make to the survival of the other species that accompany us on this living planet. But the difference could hardly be small. And we humans ourselves—simultaneously the threat to, and the caretaker of, earthly life—will be among the greatest beneficiaries.

MESSAGES FOR POLICYMAKERS AND THE MEDIA

— The world's biodiversity encompasses the vast array of genes, species, and ecosystems that sustain and give meaning to human life. Clean air, uncontaminated water, healthy crops — all of these depend on the diversity and maintenance of our biological resources.

— Human activities are now affecting species of all types and habitats, at all points of the globe, and pushing many toward extinction

— According to best estimates, extinction rates during the past century range between 100 and 1000 times faster than the background rate of species extinction.

— The bulk of evidence suggests that human population growth is an important underlying cause of biodiversity loss.

— The growth of our species' numbers is tightly coupled to rising demand for food and shelter. Increasing the supply of these essentials affects biodiversity.

— Much of current rapid human population growth is occurring in the vicinity of some of the world's biologically richest yet most vulnerable habitats.

— According to the most recent projections, by the end of the 21st century human population could reach as high as 16 billion or as low as 5.5 billion. Where our numbers end up in this range could make a critical difference to the prospects for conserving the remainder of the world's biological diversity.

— Among global trends affecting biodiversity, the most hopeful is the recent slowing of human population growth. Stabilization of human numbers, a possibility within the next forty years, would dramatically improve the prospects for saving wild species and the ecosystems in which they live and evolve.

— The United States made a commitment at the United Nations Population Conference in Cairo in 1994 to support international family planning efforts. The United States should re-establish a leadership role in family planning funding and set an example for both donor and recipient countries.

[This information update is based primarily on Population Action International's 2000 report "Nature's Place: Human Population and the Future of Biological Diversity" by Richard P. Cincotta and Robert Engelman. To order the full text of this report, please visit the PAI website at http://www.populationaction.org. Katie Mogelgaard summarized the information. Richard P. Cincotta, Nancy Cole, and Peter Frumhoff provided review and comments.]

SOURCES

Alan Guttmacher Institute, Sharing Responsibility: Women, Society and Abortion Worldwide (New York: AGI: 1999).

Bongaarts, J., "Demographic Consequences of Declining Fertility," Science 282 (1998): 419-420.

Boserup, E., Conditions of Agricultural Growth: The Economics of Agrarian Change Under Population Pressure (Chicago: Aldine, 1965).

Brechin, S., S.C. Surapaty, L. Heydir, and E. Roflin, "protected Area Deforestation in South Sumatra, Indonesia," George Wright FORUM 11, 3 (1994): 59-78.

Bryant, D., D. Nielsen, and L. Tangley, The Last Frontier Forests: Ecosystems and Economies on the Edge (Washington, DC: World Resources Institute, 1997).

Cincotta, R.P. and R. Engleman, Nature's Place: Human Population and the Future of Biological Diversity. (Washington, DC: Population Action International, 2000).

Dompka, V., ed. Human Population, Biodiversity and Protected Areas: Science and Policy Issues (Washington, DC: American Association for the Advancement of Science, 1996).

Ehrlich, P.R. and A.H. Ehrlich, Extinction: the Causes and Consequences of the Disappearance of Species (New York: Random House, 1981).

Forester, D.J. and F.E. Machlis, “Modeling Human Factors that Affect the Loss of Biodiversity,” Conservation Biology 10, 4 (1996): 1253-1263.

Goriup, P., ed. Populations and Parks, Parks 8, 1 (1998).

Hammond, P.M., “Species Inventory,” in Global Biodiversity: Status of the Earth’s Living Resources, ed. B. Groombridge (London: Chapman and Hall, 1992), 17-39.

Hannah, L., D. Lohse, C. Hutchinson, J.L. Carr, and A. Lankerani, “A Preliminary Inventory of Human Disturbance of World Ecosystems, “ Ambio 23, 4-5 (1994): 246-250.

Hoare, R. and J, Du Toit, “Coexistence Between People and Elephants in African Savannas,” Conservation Biology 15, 3 (1999): 633-639.

May, R.M., “How Many Species Are There on Earth?,” Science 241 (1988): 1441-1449.

McNeeley, J.A. and others, “Human Influences on Biodiversity,” in Global Biodiversity Assessment, ed. V.H. Heywood (Cambridge: Cambridge Univ. Press and UNEP, 1995).

Mittermeier, R.A., N. Myers, J.B. Thomsen, G.A.B. da Fonseca, and S. Olivieri, “Biodiversity Hotspots and Major Tropical Wilderness Areas: Approaches to Setting Conservation Priorities,” Conservation Biology 12, 3 (1998): 516-520.

Mittermeier, R.A. and others, The Global Biodiversity Hotspots (Mexico, D.F.: Cemex, 1999).

Myers, N., “Population and Biodiversity,” in Population – The Complex Reality, ed. F. Graham-Smith (London, The Royal Society, 1994), 117-135.

Noss, R.F. and A.Y. Cooperrider, Saving Nature’s Legacy: Protecting and Restoring Biodiversity (Washington, DC: Island Press, 1994).

Parker, J.S.C. and A.D. Graham, “Elephant Decline: Downward Trends in African Elephant Distribution and Numbers (I & II),” International Journal of Environmental Studies 34 (1989): 13-26, 287-305.

Pimentel, D. and others, “Economic and Environmental Benefits of Biodiversity,” Bioscience 47, 11 (1997): 747-757.

Pimm, S.L., G.J. Russell, J.L. Gittleman, and T.M. Brooks, “The Future of Biodiversity,” Science 269 (1995): 347-350.

Raven, P.H. “The Politics of Preserving Biodiversity,” Bioscience 40, 10 (1990): 769-774.

Reid, W. V. “Tropical Deforestation and Species Extinction,” in How Many Species Will There Be? ed. T. C. Whitmore and J. A. Sayer (London, Chapman & Hall**,** 1992), 55-73.

Soule, M.E., “Conservation: Tactics for a Constant Crisis,” Science 253 (1991): 744-750.

Stedman-Edwards, P., The Root Causes of Biodiversity Loss: An Analytical Approach, Macroeconomics for Sustainable Development Office (Washington, DC: World Wide Fund for Nature, 1997).

Stork, N.E., “How Many Species Are There?,” Biodiversity Conservation 2 (1993): 215-232.

Stork, N.E., “Measuring Global Bioddiversity and Its Decline,” in Biodiversity II: Understanding and Protecting our Biological Resources, ed. M.L. Reaka-Kudla, D.E. Wilson, and E.O. Wilson (Washington, DC: Joseph Henry Press, 1997), 41-68.

Tsui, A.O., “Family planning programs in Asia: Approaching a Half-Century of Effort,” Asia-Pacific Population Research Reports, 8 (Honolulu, East-West Center, 1996).

United Nations Population Division, World Population Prospects: The 1998 Revision (New York: United Nations, 1998a).

United Nations Population Division, World Population Projections to 2150 (New York: United Nations, 1998b).

Vitousek, P.M. and others, “Human Appropriation of the Products of Photosynthesis,” Bioscience 36, 6 (1986): 368-373.

Wikramanayake, E.D. and others, A Conservation Assessment of the Ecoregions of the Indo-Pacific region (Washington, DC: World Wildlife Fund/US, in press).

Wilkinson, C., “Coral Reefs of the World Are Facing Widespread Devatation: Can We Prevent This Through Sustainable Management Practices?,” in Proceedings of the 7th International Coral Reef Symposium, Vol. 1 (Guam:Univ. of Guam, 1993), 11-21.

Wilson, E.O., The Diversity of Life (Cambridge, Harvard Univ. Press, 1992).

Woodroffe, R. and J.R. Ginsburg, “Conserving the African Wild Dog, Lycaon pictus. I. Diagnosing and Treating Causes of Decline,” Oryx 33, 2 (1999); 132-142.

WRI, IUCN, and UNEP, Global Biodiversity Strategy: Guidelines for Action to Save, Study and Use Earth’s Biotic Wealth Sustainably and Equitably (Washington, DC: World Resources Institute, 1992).