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ASSESSING THE EMPIRICAL BASIS OF THE "BIODIVERSITY CRISIS"

Julian L. Simon and Aaron Wildavsky

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ASSESSING THE EMPIRICAL BASIS OF THE "BIODIVERSITY CRISIS"

by Julian L. Simon and Aaron Wildavsky

EXECUTIVE SUMMARY

For several years now, the World Wildlife Fund and other wildlife interest groups have been saying such things as, "Without firing a shot, we may kill one-fifth of all species of life on this planet within the next 10 years." One problem with such assertions is that there is no scientific justification for making them. Based on the most up-to-date published data concerning species loss:

- Known extinction rates are very low;
- It is impossible to estimate even approximately how many unrecorded species may have become extinct;
- We do not know how many species exist, even to within an order of magnitude, and therefore have no basis upon which to assert that we know what percentage is going extinct;
- Relatively few attempts have been made to rigorously assess the likely magnitude of extinction rates.

Edward O. Wilson, the foremost proponent of global efforts to stem the purportedly unsustainable loss of species, says that "the extinction problem" is "absolutely undeniable." Wilson cites "literally hundreds of anecdotal reports" to support his claim. However, the very reason for the scientific method in estimating rates is that anecdotal reports are of little or no value, and often mislead the public and policymakers. Indeed, that's why expensive censuses and other data gathering instruments are employed.

However, very little work has been done in this field. A survey of the existing evidence finds the following:

- The estimated extinction rate of known species is about one every four years from 1600 to 1900;
- The estimated rate is about one a year from 1900 to 1979;

- Some scientists have "hazarded a guess" that the extinction rate may now have reached 100 species per year;

- In turn, this guessed upper limit has been used as the basis for projecting that as many as 40,000 species will be dying out annually before the year 2000.

These numbers have the power to frighten the public in a fashion that smaller numbers would not; this, in turn, prompts particular government policies that could not be otherwise justified. Nevertheless, there is no scientific justification for such use of numbers. The scare about species extinction has been manufactured in complete contradiction to the scientific data. It is truth that is becoming extinct, not species.

The known facts about biodiversity lead to the inevitable conclusions that:

- If something is unknowable at present but knowable in principle, then the appropriate thing to do is to find out;

- At present, some conservation biologists seem more intent on whipping up concern for species loss than they are in documenting the extent of that loss and analyzing the possible ramifications, if any;

- More reliable information about species loss is necessary to guide future policy decisions;

- Future policies to address species loss must include the direct and indirect costs of such policies, including the long-term costs of reduction in economic growth to a community's health.

There is now no prima facie case for any expensive species-safeguarding policy without more extensive analysis. But the question deserves deeper thought, and more careful and wide-ranging analysis, than has been done until now. As children say, just saying so does not make it so.

FOREWORD

This is the first in a series of CEI publications that will examine the debate over endangered species and biodiversity. Many environmentalists assert that the planet is experiencing a rapid acceleration in the rate of species extinctions. Drs. Simon and Wildavsky take issue with that assertion. By looking at the empirical data and contrasting it with the various claims that a "biodiversity crisis" is upon us, Simon and Wildavsky assess such claims according to the scientific method. Their conclusion is that there is no legitimate scientific basis for making them.

They are not alone. In a controversial August 1991 article in *Science*, Charles C. Mann pointed out that:

> only four of 22 predictions [of species loss] came with sufficient explanation to permit independent examination. All of the rest provide anecdotal support—or none at all. Even one prominent conservationist—who demanded anonymity, explaining that 'they'll kill me for saying this—admitted that 'the lack of data does worry me.' He then added: 'I'm absolutely sure we're right, but a gut feeling isn't much backup when you're asking people all over the world to change their lives completely.'

Making the environment, in the words of Vice President Gore, "the central organizing principle" of civilization would indeed require "people all over the world to change their lives completely." The specter of mass extinctions must therefore be connected to human self-interest to justify the Endangered Species Act, the Convention on International Trade in Endangered Species, the Earth Summit's Convention on Biological Diversity and other such governmental policies.

However, the "problem", says Martin Holdgate, director general of The World Conservation Union (IUCN), "is that we do not know how much loss of what kinds of organisms is tolerable." The need for more information is clear. Even a few conservation biologists have begun to concede that the "ecosystem services" argument leaves much to be desired. For example, in *Biodiversity*, a book edited by Harvard scientist Edward O. Wilson, David Ehrenfeld acknowledges:

> the species whose members are fewest in number, the rarest, the most narrowly distributed—in short, the ones most likely to become extinct—are obviously the ones least likely to be missed by the biosphere. Many of these species were never common or ecologically influential; by no stretch of the imagination can we make them vital cogs in the ecological machine.

Even Wilson admits this. In what he calls a "traitorous digression," according to *U.S. News & World Report*, "Wilson acknowledges that most ecosystems probably could lose a hefty fraction of their species and still function....for Wilson, the most compelling reason to fight for every scrap of biodiversity has more to do with humanity's emotional health." Thus, the concern for biodiversity generally, and species loss specifically, apparently has as much to do with moral questions as biological ones.

But the intrinsic value of a given species—or that of all species taken together—is not what Simon and Wildavsky address in this important study. Rather, they set their analytical sights on a much more ascertainable facet of the biodiversity debate—namely, how reliable is the scientific evidence behind the "biodiversity crisis", and to what extent does it exist.

"Assessing the Empirical Basis of the Biodiversity Crisis" is a continuation of Simon and Wildavsky's work on the fundamental issue of scientific proof, which first began in their chapter "On Species Loss, the Absence of Data, and Risks to Humanity," in Julian L. Simon and Herman Kahn's 1984 book, *The Resourceful Earth: A Response to 'Global 2000'*.

This CEI publication brings the earlier work of Simon and Wildavsky up to date. For example, The World Conservation Union's (IUCN) 1992 book, *Tropical Deforestation and Species Extinction*, edited by T.C. Whitmore and J.A. Sayer, is cited extensively.

Perhaps now, or sometime in the near future, a more honest and substantive debate over species loss will commence. As "biodiversity" approaches the status of a household word, it will become important to understand what is being discussed. A survey of what is known about species loss is only a first step in that direction. This study is intended to be that step.

Ike C. Sugg
Walker Fellow
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ASSESSING THE EMPIRICAL BASIS OF THE "BIODIVERSITY CRISIS"*

by Julian L. Simon and Aaron Wildavsky**

INTRODUCTION

Species extinction is a key issue for the environmental movement. It is the subject of magazine stories with titles like "Playing Dice with Megadeath" with a subhead "The odds are good that we will exterminate half the world's species within the next century." Species "loss" also is the focal point of fundraising from the public. And the Congress is asked again and again for large sums of public money to be used directly and indirectly for programs to protect wildlife and wild places.

The World Wildlife Fund says, "Without firing a shot, we may kill one-fifth of all species of life on this planet in the next 10 years."

The central assertion is that species are dying off at a rate that is unprecedentedly high, and dangerous to humanity. The World Wildlife Fund, which publicizes this issue widely, frames the proposition as follows: "Without firing a shot, we may kill one-fifth of all species of life on this planet in the next 10 years." Roughly defined as "all species of life on this planet," biological diversity is normally the rhetorical rubric under which species loss is discussed.

The issue came to scientific prominence in 1979 with Norman Myers' *The Sinking Ark*, and then was brought to an international public and onto the U. S. policy agenda by the 1980 *Global 2000 Report to the President* (referred to hereafter as "GTR"). These still are the canonical texts.

GTR forecast extraordinary losses of species between 1980 and 2000. "Extinctions of plant and animal species will increase dramatically. Hundreds of thousands of species—perhaps as many as 20 percent of all species on earth—will be irretrievably lost as their habitats vanish, especially in tropical forests." (U.S., 1980, I, p. 3).

In 1984 we reviewed the data on the observed rates of species extinction. We found that the scientific evidence was wildly at variance with

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* Extracted by Ike C. Sugg from "Species Loss Revisited", forthcoming in *The State of Humanity* (ed. by Julian L. Simon).

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the by-then-conventional wisdom, and did not provide support for the various policies suggested to deal with the purported dangers. We also reminded readers that recent scientific and technical advances—especially seed banks and genetic engineering, and perhaps electronic mass-testing of new drugs—had rendered much less crucial the maintenance of a particular species of plant life in its natural habitat than would have been the case in earlier years. But the bandwagon of the species extinction issue continues to roll with ever increasing speed.

We should strive for as clear and unbiased an understanding as possible of species loss in order to make the best possible judgments about how much time and money to spend in guarding them.

Now we revise our presentation of the empirical and theoretical situations in light of the literature that has appeared in the 1980s. We find that our earlier conclusions remain sound, and may be considered strengthened by the absence of new countervailing material coming to light since then.

These are the key questions: Are species defined with sufficient clarity so that different people can arrive at satisfactorily similar estimates? What is the history of species extinction until now? What are the most reasonable forecasts of future extinction? What will be the results of extinctions (including resulting new additions) on species diversity? What will be the economic and non-economic impacts of the expected course of species diversity?

Society properly is concerned about possible dangers to species. Individual species, and perhaps all species taken together, constitute a valuable endowment, and we should guard their survival just as we guard our other physical and social assets. But we should strive for as clear and unbiased an understanding as possible of species loss in order to make the best possible judgments about how much time and money to spend in guarding them. In a world in which this valuable activity must compete with other valuable activities, including the guarding of human life, such an understanding is of more than mere academic importance.

The importance of the topic is clear from the far-reaching extent of the policies suggested. Edward O. Wilson and Paul R. Ehrlich actually ask that governments act "to reduce the scale of human activities." More specifically, they want us "to cease 'developing' any more relatively undisturbed land," because "Every new shopping center built in the California chaparral, every hectare of tropical forest cut and burned, every swamp converted into a rice paddy or shrimp farm means less biodiversity." (1991, p. 761)

DEFINING SPECIES

Before discussing rates of extinction, we must touch on an issue that complicates such estimates—the definition of a species. Referring to the "never-ending arguments about the definition of the species category," Ernst Mayr infers that "those who do not work with species but with cells or molecules may think that the species is an arbitrary and insignificant concept in biology." He argues otherwise. "What, then," Mayr asks, "is biological classification?" "Unhappily," he concludes, "no agreement on the answer to this question exists yet among biologists." He then argues that the taxonomy is based not on the similarity of the species but on their common ancestors.

> The *Encyclopedia Britannica* defines species as "groups of individuals that resemble one another more than they resemble any others." But what constitutes "resemblance"? If we adopt the definition of "who mates with whom," we will reduce the number of species; if we give the more general definition that "species are groups of organisms sharing many traits, or characteristics in common," the classifiers have a lot of room to raise or lower the number. If we use common DNA as a criterion, we guess the number of species would greatly diminish.

Edward O. Wilson and Paul R. Ehrlich actually ask us "to cease 'developing' any more relatively undisturbed land."

SPECIES LOSS ESTIMATES

The basic forecast for loss of species comes from Thomas E. Lovejoy:

> What then is a reasonable estimate of global extinctions by 2000? Given the amount of tropical forest already lost (which is important but often ignored), the extinctions can be estimated... In the low deforestation case, approximately 15 percent of the planet's species can be expected to be lost. In the high deforestation case, perhaps as much as 20 percent will be lost. This means that of the 3-10 million species now present on the earth, at least 500,000-600,000 will be extinguished during the next two decades. (U.S., 1980, II, p. 331)

This extract summarizes a table which shows a range between 437,000 and 1,875,000 extinctions out of a present estimated total of 3-10 million species. The table in turn is based on a linear relationship running from zero percent species extinguished at zero percent tropical forest cleared, to about 95% extinguished at 100% tropical forest clearing. The main source of differences in the range of estimated losses is the range of 3-10 million species in the overall estimate.

The basis of any useful projection must be some body of experience collected under some range of conditions that encompass the expected conditions, or that can reasonably be extrapolated to the expected conditions. But none of Lovejoy's references contain any scientifically-impressive body of experience. The only published source given for his key table (U.S., 1980, Table 13-30, p. 331) is Myers' *The Sinking Ark* (1979).

Myers' summary may be taken as the basic source:

As a primitive hunter, man probably proved himself capable of eliminating species, albeit as a relatively rare occurrence. From the year A.D. 1600, however, he became able, through advancing technology, to over-hunt animals to extinction in just a few years, and to disrupt extensive environments just as rapidly. Between the years 1600 and 1900, man eliminated around seventy-five known species, almost all of them mammals and birds—virtually nothing has been established about how many reptiles, amphibians, fishes, invertebrates and plants disappeared. Since 1900 man has eliminated around another seventy-five known species—again, almost all of them mammals and birds, with hardly anything known about how many other creatures have faded from the scene. The rate from the year 1600 to 1900, roughly one species every 4 years, and the rate during most of the present century, about one species per year, are to be compared with a rate of possibly one per 1000 years during the "great dying" of the dinosaurs.

No sources are given for Myers' estimates.

Since 1960, however, when growth in human numbers and human aspirations began to exert greater impact on natural environments, vast territories in several major regions of the world have become so modified as to be cleared of much of their main wildlife. The result is that the extinction rate has certainly soared, though the details mostly remain undocumented. In 1974 a gathering of scientists concerned with the problem hazarded a guess that the overall extinction rate among all species, whether known to science or not, could now have reached 100 species per year. [Here Myers refers to *Science*, 1974, pp. 646-647]

The estimate is simply a conjecture and is not even a point estimate but rather an upper bound.

Yet even this figure seems low. A single ecological zone, the tropical moist forests, is believed to contain between 2 and 5 million species. If present patterns of exploitations persist in tropical moist forests, much virgin forest is likely to have disappeared by the end of the century, and much of the remainder will have been severely degraded. This will cause huge numbers of species to be wiped out...

Let us suppose that, as a consequence of this manhandling of natural environments, the final one-quarter of this century witnesses the elimination of 1 million species—a far from unlikely prospect. This would work out, during the course of 25 years, at an average extinction rate of 40,000 species per year, or rather over 100 species per day. The greatest exploitation pressures will not be directed at tropical forests and other species-rich biomes until towards the end of the period. That is to say, the 1990s could see many more species accounted for than the previous several decades. But already the disruptive processes are well underway, and it is not unrealistic to suppose that, right now, at least one species is disappearing each day. By the late 1980s we could be facing a situation where one species becomes extinct each hour. (1979, pp. 4-5)

We may extract these key points from the above summary quotation:

(1) The estimated extinction rate of known species is about one every four years from 1600 to 1900.

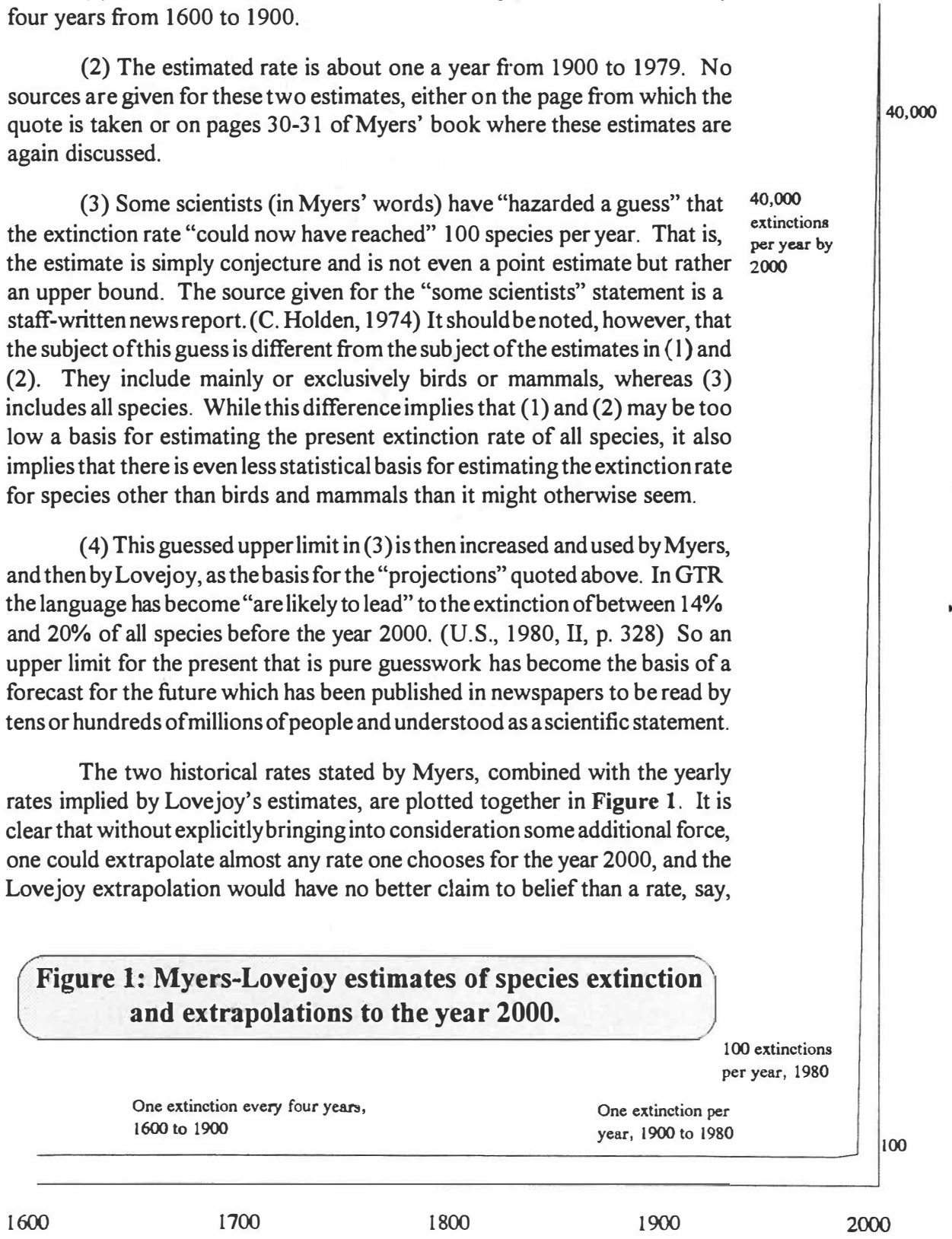
(2) The estimated rate is about one a year from 1900 to 1979. No sources are given for these two estimates, either on the page from which the quote is taken or on pages 30-31 of Myers' book where these estimates are again discussed.

(3) Some scientists (in Myers' words) have "hazarded a guess" that the extinction rate "could now have reached" 100 species per year. That is, the estimate is simply conjecture and is not even a point estimate but rather an upper bound. The source given for the "some scientists" statement is a staff-written news report. (C. Holden, 1974) It should be noted, however, that the subject of this guess is different from the subject of the estimates in (1) and (2). They include mainly or exclusively birds or mammals, whereas (3) includes all species. While this difference implies that (1) and (2) may be too low a basis for estimating the present extinction rate of all species, it also implies that there is even less statistical basis for estimating the extinction rate for species other than birds and mammals than it might otherwise seem.

(4) This guessed upper limit in (3) is then increased and used by Myers, and then by Lovejoy, as the basis for the "projections" quoted above. In GTR the language has become "are likely to lead" to the extinction of between 14% and 20% of all species before the year 2000. (U.S., 1980, II, p. 328) So an upper limit for the present that is pure guesswork has become the basis of a forecast for the future which has been published in newspapers to be read by tens or hundreds of millions of people and understood as a scientific statement.

The two historical rates stated by Myers, combined with the yearly rates implied by Lovejoy's estimates, are plotted together in **Figure 1**. It is clear that without explicitly bringing into consideration some additional force, one could extrapolate almost any rate one chooses for the year 2000, and the Lovejoy extrapolation would have no better claim to belief than a rate, say,

Figure 1: Myers-Lovejoy estimates of species extinction and extrapolations to the year 2000.



one hundredth as large. Looking at the two historical points alone, many forecasters would be likely to project a rate much closer to the past than to Lovejoy's, on the basis of the common wisdom that in the absence of additional information, the best first approximation for a variable tomorrow is its value today, and the best second approximation is that the variable will change at the same rate in the future that it has in the past. The uncertainty about the definition of species merely adds to this confusion.

Projected change in the amount of tropical forests implicitly underlies the differences between past and projected species-loss rates in Lovejoy's diagram. But to connect this element logically, there must be systematic evidence relating an amount of tropical forest removed to a rate of species reduction. We have found no reports of such empirical evidence. A recent survey document (Reid and Miller, 1989) says that "A useful rule of thumb is that if a habitat is reduced by 90 percent in area, roughly one-half of its species will be lost" (p. 35), and refers to a figure and an appendix, but no empirical studies are referred, only speculation. The only empirical observation we found is by Lugo for Puerto Rico, where "human activity reduced the area of primary forests by 99%, but, because of coffee shade and secondary forests, forest cover was never below 10 to 15%. This massive forest conversion did not lead to a correspondingly massive species extinction, certainly nowhere near the 50% alluded to by Myers." (1989, p. 28).

An upper limit that is pure guesswork has become the basis of a forecast which has been published in newspapers and read as a scientific statement.

All this implies that there is no basis to choose between a) Lovejoy's huge projected rates of extinction, and b) modest rates continuing about the same as in the past — and this is the difference between the basis for recommending various national policies and not making any recommendations at all. (Again, this is not to say that no protection policies should be undertaken. Rather, it implies that other sorts of data to estimate extinction rates are needed as the basis for policy decisions.)

COUNTERVAILING DATA

The discussion so far is about the way that matters stood when we wrote our 1984 article on the subject. In response to the questions that we and others have raised, the World Conservation Union (IUCN) commissioned a book, *Tropical Deforestation and Species Extinction* (1992), edited by Whitmore and Sayer, to inquire into the extent of extinctions. The results of that project must be considered amazing. All the authors continue to be concerned about the rate of extinction. Nevertheless, they agree that the rate of known extinctions has been and continues to be very low. This is a sampling of quotations (with emphasis added) from the book, first on the subject of the estimated rates:

... 60 birds and mammals are known to have become extinct between 1900 and 1950. (Reid, 1992, p. 55)

It is a commonplace that forests of the eastern United States were reduced over two centuries to fragments totalling 1-2% of their original extent, and that during this destruction, only three forest birds went extinct—the Carolina parakeet (*Conuropsis carolinensis*), the ivory-billed woodpecker (*Campephilus principalis principalis*), and the passenger pigeon (*Ectopistes migratorius*). Although deforestation certainly contributed to the decline of all three species, it was probably not critical for the pigeon or the parakeet (Greenway, 1967). *Why, then would one predict massive extinction from similar destruction of tropical forest?* (Simberloff, 1992, p. 85)

IUCN, together with the World Conservation Monitoring Centre, has amassed large volumes of data from specialists around the world relating to species decline, and it would seem sensible to compare these more empirical data with the global extinction estimates. In fact, these and other data indicate that *the number of recorded extinctions for both plants and animals is very small...* (Heywood and Stuart, 1992, p. 93)

In Puerto Rico, "massive forest conversion did not lead to a correspondingly massive species extinction."

Known extinction rates are very low. Reasonably good data exist only for mammals and birds, and the current rate of extinction is about one species per year (Reid and Miller, 1989). If other taxa were to exhibit the same liability to extinction as mammals and birds (as some authors suggest, although others would dispute this), then, if the total number of species in the world is, say, 30 million, the annual rate of extinction would be some 2300 species per year. This is a very significant and disturbing number, but it is much less than most estimates given over the last decade. (Heywood and Stuart, p. 94)

... [I]f we assume that today's tropical forests occupy only about 80% of the area they did in the 1830s, *it must be assumed that during this contraction, very large numbers of species have been lost in some areas. Yet surprisingly there is no clear-cut evidence for this....* Despite extensive inquiries we have been unable to obtain conclusive evidence to support the suggestion that massive extinctions have taken place in recent times as Myers and others have suggested. On the contrary, work on projects such as Flora Meso-Americana has, at least in some cases, revealed an increase in abundance in many species (Blackmore, pers. comm. 1991). An exceptional and much quoted situation is described by Gentry (1986) who reports the quite dramatic level of evolution in situ in the Centinela ridge in the foothills of the Ecuadorian Andes where he found that at least 38 and probably as many as 90 species (10% of the total flora of the ridge) were endemic to the 'unprepossessing ridge'. However, the last patches of forest were cleared subsequent to his last visit and 'its prospective 90 new species have already passed into botanical history', or so it was assumed. Subsequently, Dodson and Gentry (1991) modified this to say that an undetermined number of species at Centinela are apparently extinct, following brief visits to

other areas such as Lita where up *to 11 of the species previously considered extinct were refound*, and at Poza Honda near La Mana where six were rediscovered. (Heywood and Stuart, 1992, p. 96)

"Closer examination of the existing data supports the affirmation that little or no species extinction has yet occurred."

... *the group of zoologists could not find a single known animal species which could be properly declared as extinct*, in spite of the massive reduction in area and fragmentation of their habitats in the past decades and centuries of intensive human activity. A second list of over 120 lesser-known animal species, some of which may later be included as threatened, show no species considered extinct; and the older Brazilian list of threatened plants, presently under revision, also indicated no species as extinct (Cavalcanti, 1981). (Brown and Brown, 1992, p. 127, citation in the original)

Closer examination of the existing data on both well and little-known groups, however, *supports the affirmation that little or no species extinction has yet occurred* (though some may be in very fragile persistence) in the Atlantic forests. Indeed, an appreciable number of species considered extinct 20 years ago, including several birds and six butterflies, have been rediscovered more recently. (Brown and Brown, 1992, p. 128)

And here are some comments from that volume on the lack of any solid basis for estimation:

... How large is the loss of species likely to be? *Although the loss of species may rank among the most significant environmental problems of our time, relatively few attempts have been made to rigorously assess its likely magnitude*. (Reid, 1992, p. 55)

"It is impossible to estimate even approximately how many species have become extinct."

It is impossible to estimate even approximately how many unrecorded species may have become extinct. (Heywood and Stuart, p. 95)

While better knowledge of extinction rates can clearly improve the design of public policies, it is equally apparent that *estimates of global extinction rates are fraught with imprecision. We do not yet know how many species exist, even to within an order of magnitude*. (Reid, 1992, p. 56)

The best tool available to estimate species extinction rates is the use of species-area curves. This approach has formed the basis for almost all current estimates of species extinction rates. (Reid, 1992, p. 57)

There are many reasons why recorded extinctions do not match the predictions and extrapolations that are frequently published... (Heywood and Stuart, 1992, p. 93)

ANTHROPOGENIC IMPACTS?

In the case of species extinction, as with many other public issues, there is a tendency—in both technical discussion and in the press—to focus only upon the bad effects, and to exclude from consideration possible good effects of human activities. For example, Lugo notes that "Because humans have facilitated immigration [of species] and created new environments, exotic species have successfully become established in the Caribbean islands. This has resulted in a general increase in the total inventories of bird and tree species." (1989, p. 30) In tropical Puerto Rico where "human activity reduced the area of primary forests by 99%," as great a reduction as could be imagined, "seven bird species... became extinct after 500 years of human pressure... and ... exotic [newly resident] species enlarged the species pool. More land birds have been present on the Island in the 1980s (97 species) than were present in pre-Colombian time (60 species)." (pp. 28 and 29)

Perhaps conservation biologists make mention of the extinctions, but not of the newly-resident species, because "there is a clear aversion to exotic [newly resident] species by preservationists and biologists (in cases such as predatory mammals and pests, with good reason!)." (Lugo, 1989, p. 30) This aversion to new species may involve the idea that humankind is somehow artificial and not "natural." Consider the language of Myers, who has played as important a role as any person in raising the alarm about species extinction: "[W]hereas past extinctions have occurred by virtue of natural processes, today the virtually exclusive cause is man." (1989, p. 42) If, however, it is species diversity that is at issue rather than only preserving species as they are today, then new species should count for as much as old ones.

If it is species diversity that is at issue rather than only preserving species as they are today, then new species should count for as much as old ones.

Maintaining the Amazon and other areas in a state of stability might even have counterproductive results for species diversity, according to a recent body of research. Natural disturbances, as long as they are not catastrophic, may lead to discontinuity in environments and to consequent isolation of species that may "facilitate ever-increasing divergence." (Colinvaux, 1989, p. 103) Colinvaux goes on to suggest that "the highest species richness will be found not where the climate is stable but rather where environmental disturbance is frequent but not excessive." The same line of analysis leads to possible benefits from interventions by humankind.

During the 1980s there has been increasing recognition that the rate of species loss really is not known. Myers now writes, "Regrettably we have no way of knowing the actual current rate of extinction in tropical forests, nor can we even make an accurate guess." And Colinvaux refers to the extinctions as "incalculable." (1989, p. 102) One would think that this state of affairs would make anyone leery about estimating future extinctions. Nevertheless Myers continues, "But we can make substantive assessments by looking at species numbers before deforestation and then applying the analytical tech-

niques of biogeography ... According to the theory of island biogeography, we can realistically reckon that when a habitat has lost 90% of its extent, it has lost half of its species." (1989, p. 43) But this is mere speculation. [*see* Endnote 1]

Confirmation of the absence of scientific evidence for rapid species extinction is implicit in the nature of the "evidence" cited by, for example, Edward 0. Wilson. He says that "the extinction problem" is "absolutely undeniable". But all he cites are "literally hundreds of anecdotal reports." [*see* Endnote 1] The very reason for the scientific method in estimating rates is that anecdotal reports are of little or no value, and often mislead the public and policymakers; that's why expensive censuses and other data gathering instruments are employed.

Colinvaux refers to the extinctions as "incalculable." One would think that this state of affairs would make anyone leery about estimating future extinctions.

Some conservationists have become frustrated at their inability to document a rapid rate of species extinction that would justify calls for government regulation and funding; they also are annoyed at our writing about the actual state of the evidence. As a prominent conservationist responded to our article, "documenting degree of threat is often difficult, and economists and others who wish to downplay the risk of an extinction crisis can easily dispute this case or that case, casting doubt even on the claim that 5 percent of the world's birds are threatened." (Diamond, 1989, p. 41) Diamond therefore has suggested looking at the evidential issue in an entirely different fashion, one which is quite out of keeping with ordinary scientific practice. Normally, he writes:

> species are to be considered extant until proven extinct... [But] For most species of the tropics or other remote regions—that is, for most of the world's species a more appropriate assumption would be 'extinct unless proven extant.' We biologists should not bear the burden of proof to convince economists advocating unlimited human growth [an inaccurate description of one of the authors of this survey] that the extinction crisis is real. Instead, it should be left to those economists to fund research in the jungles that would positively support their implausible claim of a healthy biological world." (p. 41)

This is an interesting twist, a "reversal of proof burden", as Western puts it. (Western, 1989, p. 33) It implies that it is enough for a warning to be sounded, a charge to be made, for the community to proceed as if the case has been proven. If someone says that the forest floor has turned to blue cheese, and advocates that the government should immediately begin to package and sell the cheese, it is the responsibility of those who question this policy to demonstrate that the blue cheese transformation has not taken place. This intellectual strategy suggests that the biologists now despair of making their case with the usual tools of scientific inquiry, and ask instead for support on the basis of non-evidential faith.

To go one step further: The preservationists premise their forecast of rapid species extinction on there being, now and in the future, a rapid rate of

deforestation. We repeat that even if the rate of deforestation were indeed rapid, there would still be little or no basis for inferring a rate of species extinction of Lovejoy's projected magnitude. But their line of argument is rendered even less believable by the fact that the historical evidence does not support their projections of deforestation. [*see* Endnote 2]

SOME OTHER ISSUES

1. Perhaps we should look backwards and wonder: Which species were extinguished when the settlers clear-cut the Middle West of the United States? Are we the poorer now for their loss? Obviously we do not know the answers. But can we even imagine that we would be enormously better off with the persistence of any hypothetical species? It does not seem likely. This casts some doubt on the economic value of species that might be lost elsewhere.

Wilson says that "the extinction problem" is "absolutely undeniable." But all he cites are "literally hundreds of anecdotal reports."

2. It is difficult to have a reasoned argument with biologists on species extinction. One reason is that they require an almost religious test of fealty and credentials before they will consider a person's testimony as relevant. The mention of a person's original training comes up again and again. In the recent survey volume which he co-edited, Western (1989, p. 33) writes: "The implications of an extinction spasm are also debatable, among both biologists and non-biologists." And Diamond says: "Our current concern with extinction is sometimes 'pooh-poohed' by non-biologists with the one-liner 'Extinction is the natural fate of species'." (1989, p. 37) In our view, the understanding of data is not the private province of any discipline, and the background of the analyst is not a test of the validity of the analysis. But as long as it is a criterion for biologists, the issue cannot be said to be debated rationally.

Another difficulty is that conservation biologists' goals with respect to species diversity are not easy to understand. Sometimes they emphasize the supposed economic benefits of species diversity. For example, in its widely distributed 1990 fundraising letter (four letters received by the household of one of the present authors) the World Wildlife Fund asks, "Why should you care about the fate of these forests thousands of miles away?" and answers, "Because not only do they provide food and shelter to at least half the world's species of wildlife, these tropical forests are also the world's largest 'pharmaceutical factory'—the sole source of life-saving medicines like quinine, man's most potent weapon against malaria. Hundreds of thousands of people owe their lives today to these precious plants, shrubs, and trees. What would we do without them?" Diamond answers similarly: "We need them to produce the oxygen we breathe, absorb the carbon dioxide we exhale, decompose our sewage, provide our food, and maintain the fertility of our soil." (1990, p. 59)

But Quinn and Hastings say that "maximizing total species diversity is rarely if ever the principal objective of conservation strategies. Other aesthetic, resource preservation, and recreational values are often more important." (1987, p. 199) And Lovejoy says, most inclusively:

> What I'm talking about is rather the elusive goal of defining the minimum size [of habitat] needed to maintain the characteristic diversity of an ecosystem over time. In other words, I think the goals of conservation aren't simply to protect the full array of plant and animal species on the planet, but rather also to protect them in their natural associations so that the relationships between species are preserved and the evolutionary and ecological processes are protected. (quoted in Iker, 1982, p. 29)

Normally, Diamond writes, "species are to be considered extant until proven extinct. . . . [But] a more appropriate assumption would be 'extinct until proven extant.'"

This vagueness of goals makes it very difficult to compare the worth of a species-saving activity against another value. What are the relative worths of maintaining the habitat on Mount Graham, Arizona, for about 150 red squirrels which could be kept alive as a species elsewhere, for example, versus using 24 acres for an observatory that would be at the forefront of astronomical science? (*New York Times*, March 8, 1990, p. A-1) There is much less basis here for a reasoned judgment in terms of costs and benefits than there is even with such thorny issues as electricity from nuclear power versus that from coal, or decisions about supporting additional research on cancer versus using the funds for higher Social Security payments or for defense or even for lower taxes.

Policymaking is also made difficult by preservationists asserting on the one hand that the purpose of preservation is that it is good for human existence, and on the other hand that human existence must be limited or reduced because it is bad for the other species. "There are many realistic ways we can avoid extinctions, such as by preserving natural habitats and limiting human population growth" (Diamond, 1990, p. 59) is a typical statement of that sort—by the same writer who urges that humans should preserve the species because humans need them for existence!

Still another difficulty in conducting reasoned discussion of the subject with biologists is their attitude toward economists, whose trade it is to assess the economics of supporting public programs. One of the most noted of conservation biologists, Peter Raven, views economists as follows: "Perhaps the most serious single academic problem in the world is the training of economists." (1988, p. 229) We have plenty of complaints ourselves about the training of economists, but our complaint is that the fundamental truths about the subject get lost in technical escalations. The complaint of Raven and other biologists is more far-ranging: They believe that the fundamental structure of thought of economics is perverted because it leads to unsound social choices by omitting considerations the biologists consider crucial. But the conservationists do not render those considerations into a form that a calculus of choice can deal with. Herein lies a major problem for the issue at hand.

3. The view that the interests of humans and of other species are opposed leads to humankind being seen in a rather ugly light. "[O]ur species has a knack for exterminating others, and we're become better killers all the time." (Diamond, 1990, p. 58) A recent article is entitled "Extinction on Islands: Man as a Catastrophe." (Olson, 1989, p. 5)

4. It is quite clear that species are seen by many as having value quite apart from any role they play in human life, a value that is seen as competitive with the value of human life. Raven writes, "Although human beings are biologically only one of the millions of species that exist on Earth, we control a highly disproportionate share of the world's resources," (1988, p. 212) suggesting that it is unfair that we "control" more resources than do eagles, mosquitoes, or the AIDS virus.

These beliefs lead to policy recommendations toward the human race which hinge upon values about the worth of humans versus the worth of other species. And let no one doubt that the policies recommended are radical. For example, Wilson and Ehrlich suggest that "nothing less than the kind of commitments so recently invested in the Cold War could possibly suffice to accomplish" the goal of preserving biodiversity. (1991, p. 761) In a time of heightened fiscal awareness, would Americans actually be willing to invest trillions of dollars in an endeavor that may very well be unwarranted?

Wilson and Ehrlich suggest that "nothing less than the kind of commitments so recently invested in the Cold War could possibly suffice to accomplish" the goal of preserving biodiversity.

5. It is not the case, as some have asserted, that we "wish to downplay the risk of an extinction crisis." (Diamond, 1989, p. 41) Rather, we want to make as clear as possible how great the risk is. We want to separate the available facts from the guesswork and the purposeful misstatements, in order to improve the public decision-making process. And we want to comment upon how society may reasonably take into account the economic and non-economic worths of species, in light of our values for human and non-human aspects of nature and other aspects of life on earth. More generally, we would like to move the discussion in the direction of thinking as well as we can about this problem that is indeed difficult to think about sensibly, though it is probably much easier to think about than the greenhouse issue, which is much less subject to experimentation and observational comparison because there is only one atmosphere, whereas there are many separated areas whose diversity can be studied.

SUMMARY AND CONCLUSION

The scare about species extinction has been manufactured in complete contradiction to the scientific data. The highest proven observed rate of extinction until now is only *one* species per year. Yet the "official" forecast has been *40,000* species dying out per year in this century—a million in all. It is truth that is becoming extinct, not species.

The scare about species extinction has been manufactured in complete contradiction to the scientific data.

Some argue that because we do not know how many species are being extinguished, we should therefore take steps to protect them. Such reasoning is logically indistinguishable from the argument that because we do not know at what rate the angels dancing on the head of a pin are dying off, we should undertake vast programs to preserve them. And it smacks of the "spectral evidence" against "afflicted" young girls who were condemned to death for witchcraft in Salem—charges that the accused could not rebut with any conceivable material evidence.

If something is unknowable at present but *knowable in principle*, then the appropriate thing to do is to find out. This does not necessarily mean finding out by direct observation only. A solid chain of empirical evidence can lead to a reasonable conclusion. But there must be some modicum of reasonableness, in terms of both logic and evidence.

If something is *unknowable in principle*, at least with contemporary techniques, then there is no warrant for any public actions whatsoever. To assert otherwise is to open the door to public actions and expenditures on behalf of anyone who can generate an exciting and frightening hypothetical scenario.

There is now no prima facie case for an expensive species-safeguarding policy without more extensive analysis.

Some say the numbers do not matter scientifically. The policy implications would be the same, they say, even if the numbers were different by several orders of magnitude. But if so, why mention any numbers at all? The answer, quite clearly, is that these numbers do matter in one important way: they have the power to frighten the public in a fashion that smaller numbers would not. We can find no scientific justification for such use of numbers.

Some have said, but was not Rachel Carson's *Silent Spring* an important force for good even though it exaggerated? Maybe so. But the account is not yet closed on the indirect and long-run consequences of ill-founded concerns about environmental dangers. And it seems to us that, without some very special justification, there is a strong presumption in favor of stating the facts as best we know them, especially in a scientific context, rather than in any manipulation of them.

At a time when there appear frequent reports on the extraordinary possibilities of genetic engineering (for example, "Animals Altered to Produce Medicine in Milk ... Scientists Say Rare Drugs Could be Manufactured with Relative Ease," *The Washington Post*, August 27, 1991, p. 1), it is beginning to seem ludicrous to justify extraordinary expenditures for protecting an animal like the red squirrel—which may not even be genetically unique—on the grounds that its gene pool will be valuable for human life in the future.

To ignore the indirect costs of species protection because they are hard to estimate would be no more reasonable than ignoring the loss of species that we have not as yet identified.

Still, the question exists: How should decisions be made, and sound policies formulated, with respect to the danger of species extinction? We do not offer a full answer. One cannot simply propose saving all species at any cost, any more than one can propose a policy of saving all human lives at any cost.

Then we must also try to get more reliable information about the number of species that might be lost with various forest changes. This is, of course, a very tough task, too, one that might exercise the best faculties of a statistician and designer of experiments. One suggestion: if the population sizes of selected species could be measured in a series of periods along with experimental or non-experimental changes in habitats, extrapolation might teach something about conditions that would cause species to approach or reach extinction.

Lastly, policy analyses concerning species loss must explicitly evaluate the total cost of, for example, cessation of foresting in an area. And such a total cost estimate must include the long-run indirect costs of reduction in economic growth to a community's health [*see* Endnote 3], as well as the short-run costs of foregone wood or agricultural sales. To ignore such indirect costs because they are hard to estimate would be no more reasonable than ignoring the loss of species that we have not as yet identified.

It is truth that is becoming extinct, not species.

We summarize the situation as follows: There is now no prima facie case for any expensive species-safeguarding policy without more extensive analysis than has been done heretofore. But the question deserves deeper thought, and more careful and wide ranging analysis, than has been done until now. As children say, just saying so does not make it so.

ENDNOTES

1. Additional criticism of the "biogeography" theory of extinction rates has recently been reported in *Science* (Charles C. Mann, "Extinction: Are Ecologists Crying Wolf?" *Science*, 16 August, 1991, vol. 253, 736-738), but further discussion is beyond the scope of this paper.

2. See Roger A. Sedjo and Marion Clawson, "Global Forests", in *The Resourceful Earth*, (New York: Basil Blackwell, 1984).

3. See Aaron Wildavsky, *Searching for Safety* (New Brunswick, NJ: Transaction Press, 1988); see also Ralph L. Keeney, "Mortality Rates Induced by Economic Expenditures," *Risk Analysis* 10 (December 1990): 147-48, 155.

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REFERENCES

Atkinson, Ian, "Introduced Animals and Extinctions," in *Conservation for the Twenty-first Century*, Edited by David Western and Mary C. Pearl (New York, Oxford: Oxford University Press, 1989).

Brown, K. S., and G. G. Brown, "Habitat alteration and species loss in Brazilian forests," in Whitmore, T. C., and J. A. Sayer, 1992, pp. 119-142.

Colinvaux, Paul A., "The Past and Future Amazon," in *Scientific American*, May 1989, pp. 102-8.

De Beijer, J. R., "Brazil," *World Wood Review*, July, 1979, pp. 38-39.

Diamond, Jared, "Overview of Recent Extinctions," in *Conservation for the Twenty-first Century*, Edited by David Western and Mary C. Pearl (New York, Oxford: Oxford University Press, 1989).

Diamond, Jared, "Playing Dice With Megadeath," in *Discover*, April 1990, pp. 55-59.

Ehrlich, Paul and Anne, *Extinction* (New York: Random House, 1981).

Ehrlich, P., and E.O. Wilson, "Biodiversity Studies: Science and Policy", *Science*, vol.253, August 16, 1991, pp. 758-762.

Fyfe, W. S., "The Environmental Crisis: Quantifying Geosphere Interactions," *Science*, Vol. 213, 3 July, 1981, pp. 105-110.

Heywood, V. H., and S. N. Stuart, "Species extinctions in tropical forests," in Whitmore, T. C., and J. A. Sayer (1992), pp. 91-118.

Holden, Constance, "Scientists Talk of the Need for Conservation and an Ethic of Biotic Diversity to Slow Species Extinction," *Science*, May, 1974, pp. 647-648.

Iker, Sam, "Islands of Life In a Forest Sea," in *Mosaic*, September/October 1982, pp. 24-29.

Instituto Brasiliero Desinuol, "Brazil," *World Wood Review*, July, 1980, pp. 56-57.

Lugo, Ariel E., Editor, "Diversity of Tropical Species," in *Biology International*, Special Issue, 1989.

Muthoo, M. K., "Brazil," *World Wood Review*, May, 1978, pp. 51-53.

Myers, Norman, *The Sinking Ark* (New York: Pergamon, 1979).

Myers, Norman, "A Major Extinction Spasm: Predictable and Inevitable?", in *Conservation for the Twenty-first Century*, Edited by David Western and Mary C. Pearl (New York, Oxford: Oxford University Press, 1989).

Olson, Storrs L., "Extinction on Islands: Man as a Catastrophe," in *Conservation for the Twenty-first Century*, Edited by David Western and Mary C. Pearl (New York, Oxford: Oxford University Press, 1989).

Persson, R., *World Forest Resources* (Stockholm: Royal College, 1974).

Quinn, James F. and Alan Hastings, "Extinction in Subdivided Habitats," in *Conservation Biology*, Volume 1, No. 3, October 1987, pp. 198-208.

Raven, Peter H., "The Cause and Impact of Deforestation," in *Earth '88 Changing Geographic Perspectives*, 1988, pp. 212-229.

Reid, W. V., "How Many species will there be?," in Whitmore, T. C., and J. A. Sayer 1992), pp. 55-74.

Reid, Walter V., and Kenton R. Miller, *Keeping Options Alive: The Scientific Basis for Conserving Biodiversity*, (World Resources Institute, October 1989).

Rohter, Larry, "Amazon Basin's Forests Going Up in Smoke," *The Washington Post*, January 5, 1979, A14.

Roush, G. Jon, "The Disintegrating Web: The Causes and Consequences of Extinction," pp. 4-15.

Sedjo, Roger A., "Forest Plantations in Brazil and Their Possible Effects on World Pulp Markets," *Journal of Forestry*, 78, November, 1980, 702-704.

Simberloff, D., "Do species-area curves predict extinction in fragmented forest?," in Whitmore, T. C., and J. A. Sayer, 1992, pp. 75-90.

Sommer, Adrian, "Attempt at an Assessment of the World's Tropical Mist Forests," *Unasylva*, 28, 1976, pp. 5-27.

U.S. CEQ and Department of State, *The Global 2000 Report to the President*, Vol. II, (Washington: GPO, 1980).

U.S. CEQ and Department of State, *Global Future: Time to Act* (Washington: GPO, 1981).

Waldrop, M. Mitchell, "Wood: Fuel of the Future?", *Science*, February 27, 1981, p. 914.

Western, David, "Conservation Biology," in *Conservation for the Twenty-first Century*, Edited by David Western and Mary C. Pearl (New York, Oxford: Oxford University Press, 1989).

Whitmore, T. C., and J. A. Sayer, eds., *Tropical Deforestation and Species Extinction* (Chapman and Hall, 1992).

Whittaker, R. H., and G. E. Likens, "The Biosphere and Man," in H. Lieth and R. H. Whittaker (eds.), *Primary Productivity of the Biosphere* (New York: Springer, 1975).