# 3

# Conservation and Human Population Growth: What Are the Linkages?

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## Summary

This chapter offers an overview of the demographic, economic, environmental, and cultural situation of the human species today, then takes a closer look at the distribution of human population density in relation to farming systems. Current views of the relation between conservation and human population growth range from a denial or neglect of any connection whatsoever to an assertion that population growth is the main cause of conservation problems. Although both extreme views may be appropriate sometimes, human interactions with the environment are in general strongly influenced by economics and culture, and rapid population growth makes it more difficult to preserve many aspects of environmental quality. Conservationists need an external agenda that shapes the positions they will support in other fields that affect conservation, such as family planning, agriculture, education, and environmental law. To promote discussion of the external agenda of conservation, I put forward a few proposals.


## Introduction

At least six listed participants in this meeting have dealt in print with conservation and human population growth. In 1975, Gene Likens published with Robert Whittaker a classic article on "The Biosphere and Man." They concluded that the biosphere could feed generously a human population stabilized at a low enough level, but that if people failed to stabilize their population, the poor countries could become trapped in poverty, the rich countries in a degraded environment, and the whole world in trouble (Whittaker and Likens, 1975). In 1991, Michael L. Pace and colleagues showed that "on a global scale, human population within a river's watershed is strongly related to the concentration of nitrate in rivers that discharge to coastal ecosystems" (Peierls et al., 1991; see also Cole et al., 1993). In 1993, Gary Meffe, together with Anne Ehrlich and David Ehrenfeld, lamented that not one paper that dealt directly with human population growth had been submitted for publication in the journal *Conservation Biology* (Meffe et al., 1993). Also in 1993, Steward Pickett observed that "American ecology has largely ignored humans. . . . But human effects, both subtle and conspicuous are being increasingly documented at all spatial scales" (in Jolly and Torrey, 1993:37–38). In his presidential address to the Ecological Society of America in 1994, Ronald Pulliam focused on "human population growth and the carrying capacity concept." He estimated that "a Brazilian Amazon population of . . . 200 million would result in 100 percent deforestation and the loss of all endemic forest interior species" (Pulliam and Haddad, 1994:154). In this volume, Judy L. Meyer observes that "Humans are a part of all ecosystems."

These works and others by other participants show that I am following a trail blazed by giants. Yet it is worth revisiting this trail in the hope of seeing something new.

In a nutshell, my message is this. The effects of human population growth on conservation depend strongly on economic and social factors as well as on human numbers, density, and growth rates. Although human population growth can directly intensify the three major threats to the survival of nonhuman species—which are habitat conversion, hunting and species introductions—rapid population growth also makes it harder for a society to solve many of its political, social, environmental, and economic problems, including but not only its problems of conserving biological diversity. Conservationists need to support efforts to slow human population growth for reasons of conservation and of human well-being.

This chapter offers an overview of the demographic, economic, environmental, and cultural situation of the human species today, then takes a closer look at the distribution of human population density in relation to farming systems. Current views of the relation between conservation and human population growth range from a denial or neglect of any connection whatsoever (e.g., DeWalt et al., in Jolly and Torrey, 1993) to an assertion that population growth is the main cause of conservation problems (e.g., Popline, 1992). Although both extreme views may be appropriate sometimes, the reality in general is more complex. Conservationists need an external agenda that shapes the positions they support in fields that affect conservation. To promote the development of an external agenda for conservationists, I put forward several proposals.

## Context: Population, Environment, Economics, Culture

I begin with a global overview. Further details appear in Cohen (1995). Compared to history before World War II, the human situation is unprecedented in four respects that are relevant to conservation:

- human population size and growth;
- human impact on the environment, and vice versa;
- enormous wealth and disparities between the rich and the poor; and
- a cultural implosion of diverse traditions.

### *Population Growth*

Shortly after the last Ice Age ended about 12,000 years ago, the human population of the Earth first exceeded 5 million people. By A.D. 1650, the population grew to about 500 million. This 100-fold increase represented a doubling about once every 1,650 years, on the average. After A.D. 1650, population growth accelerated tremendously. The human population increased from roughly half a billion to roughly 5.7 billion today—about three and a half doublings in three and a half centuries, or one doubling per century. Since 1955, the population has doubled in 40 years—more than a 40-fold acceleration over the average population growth rate before 1650. Never before the second half of the twentieth century had any person lived through a doubling of global population—and now some have lived through a tripling of human numbers. Not only is the population bigger than ever before—it is growing much faster. As of 1995, the world's population would double in 45 years if it continued to grow at its present 1.5 percent per year, though that is not likely. Although this growth rate is less than the all-time peak of 2.1 percent per year in the period 1965–70, it greatly exceeds any global population growth rate before World War II. An absolute increase in population by 1 billion people, which took from the beginning of time until about 1830, now requires about 12 years.

These global totals and averages remind me of a story. The story is related to one of the main themes of this book, namely, heterogeneity. An ecologist, an economist, and a statistician went on a deer hunt with bow and arrow. Creeping through the undergrowth, they came on a deer. The ecologist took careful aim and shot. His arrow landed 5 meters to the left of the deer. The economist then took careful aim and shot. Her arrow landed 5 meters to the right of the deer. The statistician looked at the arrow to the left, the arrow to the right, and the deer, and jumped up and down shouting, "We got it! We got it!"

Global statistics conceal vastly different stories in different parts of the world. About 1.2 billion people live in the economically more developed regions: Europe, Northern America, Australia, New Zealand, and Japan. The remaining 4.5 billion live in the economically less developed regions. The population of the more developed regions grows at perhaps 0.2 percent per year, with an implied doubling time of more than 400 years. The population of the less developed regions grows at 1.9 percent per year, a rate sufficient to double in 36 years if continued. The least developed regions with the world's poorest half billion people increase at 2.8 percent per year, with a doubling time of less than 25 years. At current birth rates, the worldwide average number of children born to a woman during her lifetime (the global total fertility rate) is around 3.1. The number ranges from more than 6 in sub-Saharan Africa to 1.5 in Europe.

The populations of some domestic animals have grown even faster than human numbers. For example, the number of chickens, 17 billion, more than doubled from 1981 to 1991. In 1992, domestic animals were fed 37 percent of all grain consumed (World Resources Institute, 1994:296). Some domestic animals have major environmental impacts because they produce methane, liquid and solid wastes, overgraze fragile grasslands, and prevent forest regeneration. The human species lacks any prior experience with such rapid growth and large numbers of its own or of its domestic species. A few of the many complex connections between these growing numbers, the environment and economics are spelled out next.

*Environment*

Energy use is one simple index of both economic power and human influence on the environment. Energy use per person and population growth have interacted multiplicatively. Between 1860 and 1991, while the human population more than quadrupled from about 1.3 billion to about 5.4 billion, inanimate energy used per person grew from about 0.9 megawatt-hours per year to about 17.6 megawatt-hours per year. Global inanimate energy use (the product of population size and average energy use per person) grew nearly 100-fold from 1 billion megawatt-hours per year in 1860 to 95 billion megawatt-hours per year in 1991.

Vulnerability to environmental impacts is also increasing. For example, the impact of a projected rise in sea levels increases with the tide of urbanization, as the number of people who live in coastal cities rapidly approaches 1 billion (World Resources Institute, 1994:354). With increasing frequency, people make contact with the viruses and other pathogens of previously remote forests. Cities of unprecedented population density and increased global travel provide novel opportunities for transmission, and new diseases are emerging.

Between 1973 and 1988, while world population rose by 1.2 billion, developing countries transformed around 400,000 square kilometers of forest to farms and around 856,000 square kilometers of forest to houses, roads and factories. Deforestation in developing countries in this 15-year period totaled about 1,450,000 square kilometers, almost the area of Alaska (Harrison, 1993:9). For each additional person, the area equal to roughly one quarter of an American football field was deforested. Did the population increase during this time cause the deforestation? We'll return to that question later.

*Economic Growth*

In the aggregate production of material wealth, the half century since World War II has been a golden era of technological and economic wonders. For example, in constant prices with the price in 1990 set equal to 100, the price of petroleum fell from 113 in 1975, to 76 in 1992. The price of a basket of 33 nonfuel commodities fell from 159 in 1975, to 86 in 1992. Total food commodity prices fell from 196 in 1975, to 85 in 1992 (World Resources Institute, 1994:262).



Remember the ecologist's and economist's arrows that averaged on target? As the world's average economic well-being rose, economic disparities between the rich and the poor increased. In 1960, the richest countries with 20 percent of world population earned 70.2 percent of global income, while the poorest countries with 20 percent of world population earned 2.3 percent of global income. Thus the ratio of income per person between the top fifth and the bottom fifth was 31 to 1 in 1960. In 1970, that ratio was 32 to 1; in 1980, 45 to 1; in 1991, 61 to 1 (United Nations Development Programme 1992:36; 1994:63).

In 1992, the 830 million people in the world's richest countries enjoyed an average annual income of $22,000—a truly astounding achievement. The almost 2.6 billion people in the middle-income countries received only $1,600 each on average. The more than 2 billion people in the poorest countries lived on an average annual income of $400, or a dollar a day (Demeny, 1994:17). If you remember only two numbers from this chapter, please remember these two, based on 1992 statistics: 15 percent of the world's population in the richest countries enjoyed 79 percent of the world's income.

Dollars are not the full measure of human well-being. In 1990–95, while Europe enjoyed a life expectancy above 75 years, Africa still had a life expectancy of 53 years—below the world average 20 years earlier. In developing regions, the absolute numbers and the fraction of people who were chronically undernourished fell from 941 million, and 36 percent, around 1970 to 786 million, and 20 percent, around 1990. In Africa, contrary to the world trend, the absolute number of chronically undernourished increased by two thirds (World Resources Institute, 1994:108). Africa also had the highest population growth rates during this period, and still does.

Food commodity prices dropped by half, as I showed earlier, while nearly a billion people in developing countries chronically did not eat enough. The bottom billion have no money to buy food, so they cannot drive up its price. The asset they are able to produce most easily—an asset that they hope will help them wrest a living from often declining natural resources—is children. In developing countries, high fertility is both a cause and a consequence of poverty.

*Culture*

The cultural implosion of recent decades is the change that is potentially most explosive. Migrations within and between countries, business travel, tourism, media and telecommunications have shrunk the world stage. In 1800, roughly 2 percent of people lived in cities; today the fraction is about 45 percent. The absolute number of city dwellers rose more than 140-fold from perhaps 18 million in 1800 to some 2.6 billion today. In every continent, in giant city-systems, people who vary in culture, language, religion, values, ethnicity, and socially defined race increasingly share the same space for social, political, and economic activities. The resulting frictions are evident in all parts of the world.

This completes my overview of the current situation. Now I want to zoom in for a closer look at population density.

## The Distribution of Human Population Density: A Closer Look

In 1994, the world had an average population density on ice-free land of 0.42 people per hectare. A hectare is a square 100 meters on a side—approximately the area of two American football fields placed side by side. One square kilometer equals 100 hectares, so a population density of 0.42 people per hectare means 42 people per square kilometer, or roughly one person for every 2½ hectares.

The global average, like the arrows of the economist and the ecologist, misses the mark. In the more developed regions, the population density is 0.22 people per hectare, half the global average. In the less developed regions, the population density is 0.54 people per hectare. The countries with less wealth have a higher population density to support.

To analyze population densities in more detail, I examined 1989 data on the population and area of 148 countries (World Resources Institute, 1992). In 1989, the U.S.S.R. still existed. The combined areas and populations of these 148 countries covered almost the entire ice-free land area and human population of the Earth. I divided each country's population by its land area to get its population density, then ranked the countries from the least to the most densely populated.

In the top left panel of Figure 3.1, I added the area of all countries in which the population density was less than or equal to the population density shown. For example, nearly 13 billion hectares had an average population density of ten or fewer people per hectare. Only a tiny area had a population density greater than ten people per hectare.

To see the cumulative distribution of area at low population densities, I replotted the same data with population density on a logarithmic scale in the second row of the first column of Figure 3.1. More than 11 billion hectares had one person per hectare or fewer, and more than 10 billion hectares had on average less than half a person per hectare.

To emphasize the distribution of population density among the countries with the least dense populations, I replotted the same data a third time with both population density and cumulative area on logarithmic scales in the bottom left panel of Figure 3.1. Together these three figures give the global pattern of population density in relation to cumulative area on the scale of all nations.

What is the distribution of population density within a nation? I applied the identical treatment to the populations and areas of the states of the United States plus Washington D.C. in 1990. The three plots in the middle column of Figure 3.1 are remarkably similar to the corresponding plots for the countries of the world.

I then applied the identical treatment to the populations and areas of the 62

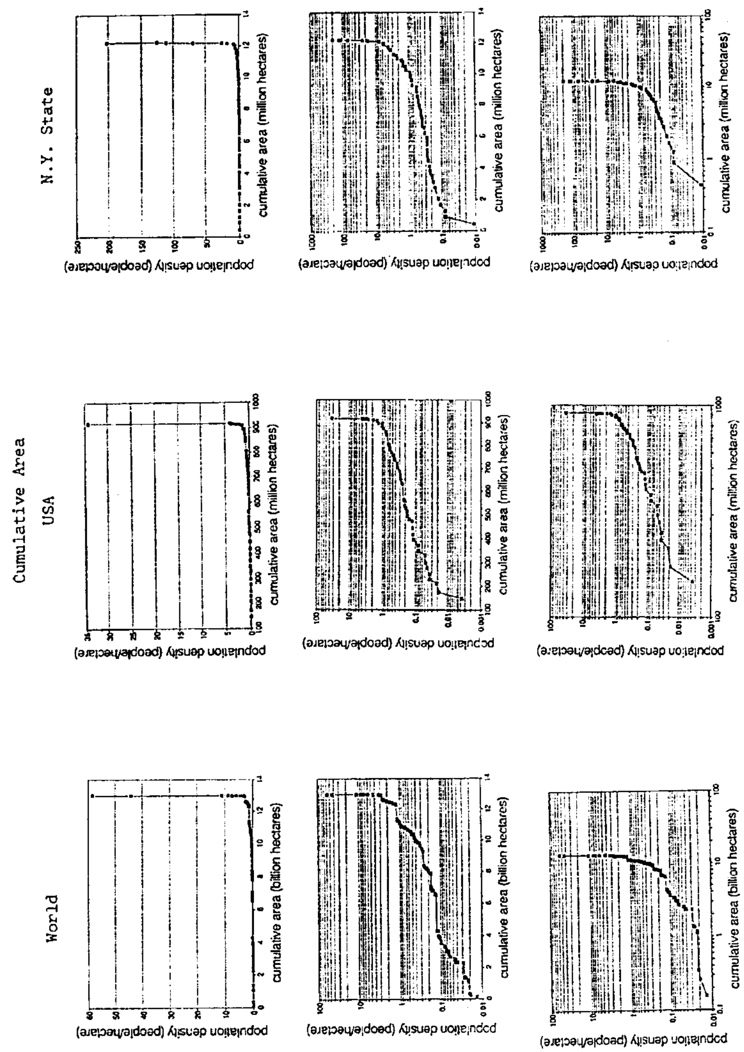


*Figure 3.1.* Cumulative land area (horizontal axis) with population density equal to or less than the value shown on the vertical axis. Left column: countries of the world in 1989 (data: World Resources Institute, 1992); middle column: 50 states of the United States plus Washington, D.C. (data: U.S. 1990 Census); right column: 62 counties of New York State (data: U.S. 1990 Census). First row: both axes are on a linear scale; second row: vertical axis is logarithmic, horizontal axis is linear; third row: both axes are on a logarithmic scale.

counties of New York State. The plots of county population density as a function of cumulative area in the right column of Figure 3.1 are similar to the plots for states and countries. The total area of New York State, a bit less than 13 million hectares, is about one-thousandth of the total ice-free land area of the world, roughly 13 billion hectares.

Based on this obviously very limited analysis, I conjecture that the distribution of human population density by area is self-similar over a thousandfold range of areas. That is, if you take the labeling off the tic marks on the axes, you cannot tell the size of units you are examining from the shape of the plotted curves. Does this observation hold for other countries and other states? for the human population at earlier times? for nonhuman species? I don't know, but I am curious to find out.

How many people lived at each level of population density in 1989? Using the same data, and replacing cumulative area by cumulative population, Figure 3.2 shows that 2 billion people lived at a population density of one person or fewer per hectare, and about 4 billion people lived at a population density of 2 people per hectare or lower. The distribution of population density within the United States including Washington, D.C., in 1990 was remarkably similar to the distribution by countries. However, the counties of New York State offered a surprise. The large 1990 populations of the five counties of New York City moved the high end of the reverse-L curve to the right, relative to the pattern of countries and states. More data on other regions are required to learn how general are the patterns I have described here.

Historically, population density has been associated with farming intensity. Farming intensity (expressed in percentages) is defined as 100 times the number of crops divided by the number of years in which the land is cultivated and fallowed in one cycle of cultivation and fallow (Pingali and Binswanger, 1987). Hunters and gatherers, who do not cultivate the land, practice a farming intensity of zero. If land is cropped once every year, the farming intensity equals 100 percent. If multiple crop cycles are completed within a single year and the land is never fallowed, the farming intensity exceeds 100 percent (Table 3.1).

A given value of farming intensity between 0 and 100 does not specify the duration of a farming cycle. For example, a farming intensity of 5 percent could mean that, on the average, each year of cultivation is followed by 19 years of fallow. It could also mean, in principle, that 5 consecutive years of cultivation are followed by 95 years of fallow. Quite different amounts of succession and forest recovery can take place under these two regimes. Thus a given value of farming intensity is consistent with very different effects on biological diversity.

In practice, forest fallow consists of one to two annual crops and 15–25 years of fallow; bush fallow of two or more crops and 8–10 years of fallow; short or grass fallow of one to two crops and 1–2 years of fallow; annual cropping of one crop per year, with fallow for only part of a year; and multicropping of two or more crops on the same land each year with no fallow (Boserup, 1981:19). Bush fallow and more intense farming systems prevent forest regeneration.

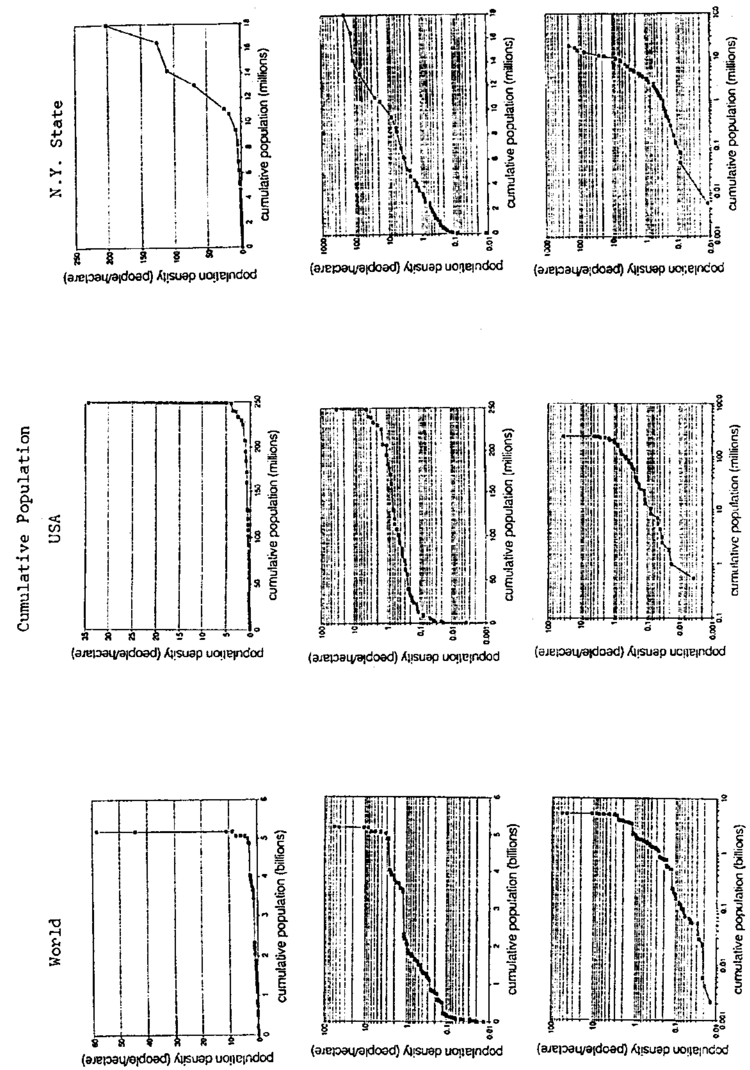


*Figure 3.2.* Cumulative population (horizontal axis) living at a population density equal to or less than the value shown on the vertical axis, by countries of the world (left column), states of the United States plus Washington, D.C. (middle column), and counties of New York State (right column). Data and linear or logarithmic scaling of the axes are the same as in Figure 3.1.

*Table 3.1. Population density, farming intensity and farming systems in low-technology countries.*

| Farming System | Farming Intensity (percent) | Population Density (people/hectare of potentially arable land) | Climate | Tools Used |
|---|---|---|---|---|
| Hunter/gatherer | 0 | 0–0.04 | | |
| Pastoralism | 0 | 0–0.04 | | |
| Forest fallow | 0–10 | 0–0.04 | humid | axe, matchet, digging stick |
| Bush fallow | 10–40 | 0.04–0.64 | humid or semihumid | above tools plus hoe |
| Short fallow | 40–80 | 0.16–0.64 | semihumid, semiarid, high altitude | hoes and animal traction |
| Annual cropping with intensive animal husbandry | 80–100 | 0.64–2.56 | semihumid, semiarid, high altitude | animal traction and tractors |
| Multicropping with little animal food | 200–300 | 2.56 and up | | |

*Sources*: Boserup (1981: 9, 19, 23); Pingali and Binswanger (1987: 29).

The Danish economist Ester Boserup (1981:23) investigated the association between population density and agricultural systems. Her definition of population density is not simply the ratio of people to all land, but rather the ratio of people to potentially arable land (Boserup, 1981:16). Potentially arable land excludes areas under ice, unirrigable deserts, and mountains too steep for terracing or pasturing, but includes land that could be developed into agricultural land with suitable investments in infrastructure, land now covered by forests that could be cleared and then farmed, grazing lands that are arable, and long-term fallow lands. This definition of "potentially arable land" is difficult, or perhaps impossible, to measure in practice. For example, who knows whether never-cleared tropical forest land will be suitable for agriculture for more than a very few years? Compromising with the available international statistics on land use, Boserup (1981:16) simply excluded land classified as "other" "only if it is likely to be arctic or desert and accounts for . . . a large share of total territory." For low-technology countries, she proposed that farming systems are associated with the population densities per area of arable land as shown in Table 3.1.

The global average population density of 0.42 people per hectare would be compatible with bush fallow or short fallow farming systems if all ice-free land were arable (an unlikely possibility, especially with low levels of technology). Domesticated land (cropland plus permanent pasture) approximated 37 percent of all land (excluding Antarctica) during 1986–89 (World Resources Institute, 1994:284). If all domesticated land is potentially arable using the low technology, then the global population density per arable land would be 0.42/0.37, that is, 1.14 people per hectare of arable land. Table 3.1 suggests that annual cropping is required when the population density exceeds 0.64 people per hectare of arable land. It follows that nearly all arable land (defined here as domesticated land) should be cropped at least annually if farmers respond to global population densities rather than to local population densities only, and if farmers use low technology. Because farmers sell food to remote dense populations, domestic and international trade and transport spread the ecological effects of locally dense populations to less populated regions. Thus the effect of global population growth on land use for agriculture, and hence on conservation, depends in part on domestic and international politics, economics and transport, and in part on the level of technology farmers use.



## Human Population Growth and Conservation

What is the connection between human population growth and conservation problems? One extreme view is that human population growth has nothing to do with conservation. This point of view is implicit in a conservation agenda that pays no attention to human population growth. Sometimes scholars explicitly deny that human population growth is responsible for conservation problems. For example, from 1970 to 1989, the population of Honduras nearly doubled from 2.63 million to 4.98 million people, while soil eroded, watersheds deteriorated, and forests and coastal resources were destroyed on a massive scale. A 1993 case study of Honduras investigated whether the rapid population increase was directly linked to the natural resource destruction (DeWalt et al., in Jolly and Torrey, 1993:106–123). The report concluded:

> In southern Honduras, environmental degradation and social problems often attributed to population pressure arise from glaring inequalities in the distribution of land, the lack of decent employment opportunities, and the stark poverty of many of the inhabitants. It is not the carrying capacity of the land that has failed to keep pace with population growth. Neither is population growth the primary cause of the impoverishment of the Honduran ecology and its human inhabitants. While the destruction caused by the poor in their desperate search for survival is alarming, it pales in comparison with the destruction wrought by large landowners through their reckless search for profit.

The authors of this study saw no connection between Honduras's extremely rapid population growth and "the lack of decent employment opportunities, and the stark poverty of many of the inhabitants."

At the opposite extreme from this study, some see human population growth as the root cause of conservation problems. For example, in a newsletter devoted to slowing population growth, the caption of a photograph of clear-cut forests read (Popline, 1992:4): "Central America's forests have diminished by more than two-thirds in the past 500 years and are expected to shrink even more as the region's population continues to grow faster than anywhere outside of Africa."

In 60 tropical countries in 1980 (excluding eight arid African countries), the larger the number of people per square kilometer, the smaller the percentage of land covered by forest. The higher the deforestation in these countries, the higher food production also; forests were cleared to open land for agriculture (Pearce and Warford, 1993:166). When 50 countries of unstated geographic distribution were ranked from high to low percentage of habitat loss in the mid-1980s, the amount of habitat loss decreased with decreasing population density, from 85 percent habitat loss and 1.89 people per hectare in the top 10 countries to 41 percent habitat loss and 0.29 people per hectare in the bottom 10 countries (Harrison, 1992:323). Statistical associations such as these suggest, but do not prove, that human population density is responsible for deforestation and the loss of tropical species.

Where relatively small areas of rain forest are surrounded by cleared land, as in Central America, the Philippines, Rwanda, and Burundi, peasants in the cleared areas expand their areas of cultivation, little by little, by nibbling away at the forests. In these cases, variations in rates of deforestation may be explained by variations in local rates of population increase (Rudel, 1991:56).

However, where there are large blocks of rainforest, population growth is not enough to explain deforestation. In addition to rapid population growth, substantial capital investment, for example, in access roads, plus an absence of enforced property rights are also necessary for rapid deforestation. Rates of deforestation were far higher during the 1970s in Brazil, which was relatively capital-rich, than in capital-poor Bolivia and Zaire. In times of economic hardship, if capital becomes scarce, fewer roads may be built in regions with large extents of rainforest. As these large tracts then remain inaccessible to most migrants from other regions, many potential migrants may stay home and pursue the nibbling form of deforestation. Hence capital scarcity may shift the location and nature of deforestation (Rudel, 1991).

When forests are cleared so the land can be farmed to feed an increasing population, the rate of cutting depends in part on how much land is required to produce food for one more person. That requirement depends on yields, farmer education, credit for agricultural investments in land and equipment, culturally acceptable crop varieties, soil types, water resources both natural and human-built, and so on through every aspect of culture and economics and the environment. Forests are sometimes cut because governments give land tenure or tax advantages to those who clear trees, and sometimes because domestic and international markets demand wood in quantities determined more by wealth and population density in cities than by human numbers in forested regions. A one-directional causal model like "human population growth causes the extinction of species" is far too simple (as emphasized by Marquette and Bilsborrow, 1994).

Of the animal extinctions since 1600, it is estimated that hunting caused 23 percent, the destruction of habitat 36 percent, the introduction of alien species 39 percent, and other factors about 2 percent (World Resources Institute, 1994:149). These proximal causes of biodiversity loss are driven in part by population growth and in part by many other factors: culturally determined demands for rhinoceros horn, ivory, and tiger bones; waste disposal in wetlands and water bodies; international trade that pushes developing countries to grow cash crops for export; faulty or insufficient scientific information about the consequence of introducing species; distorted governmental policies regarding land ownership and agricultural prices; inequities in land ownership and management; market failures in valuing unpriced ecosystem services; and inadequate legal definition and enforcement of property rights.



A 1993 report of the National Academy of Sciences on population and land use in developing countries offered the following major conclusions (Jolly and Torrey, 1993:9–11):

> In the long run, population growth almost certainly affects land use patterns. The effects of population growth occur mainly through the extensification and intensification of agricultural production. . . . Most of the changes in land use associated with very rapid population growth are likely to be disadvantageous for human beings. . . . Population growth is not the only, or in many cases, the most important influence on land use. Other influences include technological change and changes in production techniques . . . inequality itself, however, is in part influenced by rates of population growth . . . with clear property rights, robust soils, and efficient markets, population growth is less likely to result in land degradation. . . . Rapid population growth is likely to make the survival of other members of the animal and plant kingdom more difficult. Accompanying rapid population growth in the past has been greater species loss and a higher attrition within species than would have occurred in the absence of human expansion.

## The Agendas of Conservation

Conservationists need two agendas: an internal agenda and an external agenda. The internal agenda of conservation contains answers to questions like: What research is needed? Given what is known about particular conservation problems, what needs to be done? A principal aim of this book is to define and promote conservation's internal agenda.

The external agenda concerns the positions conservationists support in other fields that affect conservation. Such fields include family planning, agriculture, education, and environmental law. How conservationists define their external agenda could influence their internal agenda for research, and vice versa. To promote discussion of the external agenda of conservation, I put forward a few proposals.

A major item on the external agenda of conservation ought to be slowing human population growth voluntarily by means that simultaneously contribute to other goals. For example, the education of women in developing countries—who now get about half the education of men, on the average—could increase their productivity as workers, improve their child-rearing, and defer the age of first marriage, thereby raising the quality of their lives and also slowing population growth. Improved health facilities could simultaneously reduce infant and child mortality, removing one incentive for high fertility. Better health facilities could also lower scandalous rates of maternal mortality, improve the productivity of agricultural workers, and provide a framework for the distribution of family planning products and services.

As a second item on their external agenda, conservationists should promote the selective intensification of agriculture through nonpolluting and nondestructive means. Intensification means extracting more yield from the same area of land. Intensification would make it possible to support additional billions of people, who appear to be almost inevitable, and to improve the lot of those already born, while taking less additional land away from natural habitats. How yields are raised is all important. Methods of cultivation that erode soil and produce polluting effluents are counterproductive. Better understanding of the food webs of agroecosystems would identify the natural enemies of agricultural pests and might suggest improved nontoxic strategies for pest control (Cohen et al., 1994; Schoenly et al., 1995). Farmer education in the developing world should include natural history and practical systematics related to biological pest control as well as training in more efficient use of water.

Institutional innovation will be required. The agricultural economist Vernon W. Ruttan wrote (in Jolly and Torrey, 1993:150): "The challenge to institutional innovation in the next century will be to design institutions that can ameliorate the negative spillover into the soil, the water, and the atmosphere of the residuals from agricultural and industrial intensification."

Third, appropriate property law could make many renewable natural resources less vulnerable to open access (Hardin, 1968). When a peasant asks, "Why should I plant trees if someone else may harvest them?" it is a good question. Unless legal and institutional guarantees promote the conservation of natural resources, these resources may be mined to exhaustion like the fisheries off the Atlantic coast of the United States and Canada. Property law should enhance rather than oppose social equity, and should regulate private actions, such as clearcutting privately owned forests in a watershed, that have adverse external effects on common goods.

I hope these proposals will stimulate thinking about the external agenda of conservationists.

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# The Ecological Basis of Conservation

## Heterogeneity, Ecosystems, and Biodiversity

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