

CIVE 3331 Environmental Engineering

CIVE 3331 - ENVIRONMENTAL ENGINEERING
Spring 2003

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Purpose: Reading List for Lecture # 17

The following materials are to be acquired and read before coming to Lecture#4.

- (1) Masters, G.M., 1996. Introduction to Environmental Engineering and Science, 2nd Ed., Prentice Hall, New Jersey, 651p.

Read pp. 77-92 before Lecture #17.

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World's growth soaring

Asia, Africa lead boom, study finds

Associated Press

UNITED NATIONS — The world's population — already more than double what it was in 1950 — is projected to boom by another 3 billion in the next half-century, with Africa and Asia dwarfing Europe, even with the staggering toll of AIDS, a new U.N. study says.

Today, there are some 6.1 billion people in the world. By 2050, that figure is anticipated to swell to 9.3 billion — with nearly nine of every 10 people living in a developing country, one out of six in India alone, according to the study to be released today by the U.N. population division.

And while AIDS is projected to kill hundreds of millions more in Africa, the number of people in the world's 48 poorest nations, mostly in sub-Saharan Africa, is expected to triple in the next 50 years, the study said.

Meanwhile, dropping birthrates make it imperative for Europe and Japan to rethink their immigration policies and adjust social services to accommodate a shrinking work force and a growing elderly population, said Joseph Chamie, director of the U.N. population division.

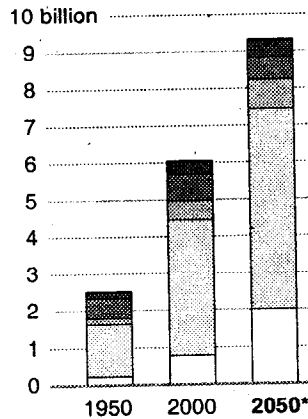
"Some people think the world population problem is over," he said. "No. This is a long-term issue and it's a very complex symphony — you have some countries declining, you have other countries growing rapidly, and you have some staying the same. When you add those up, you have a very complex world."

But Ben Wattenberg, a senior

Global growth

World population projections, by region:

- New Zealand and Australia
- North America
- Europe
- Latin America and Caribbean
- Asia
- Africa



*Projected
Source: U.N. Population Division

Associated Press

fellow at the conservative-leaning American Enterprise Institute, cautioned that the study's estimates could be "potentially misleading."

The fertility rate — the average number of children born to a woman during her childbearing years — is dropping faster and more consistently worldwide than the U.N. report suggests, making it likely that the 2050 population estimate is inflated, he said. "Their numbers are high — they should be lower."

The report said that taking into account improved economies as well as lower mortality and fertility rates, growth will be rapid in Africa, much of Asia and Latin America. The United States, with a fresh influx of 1 million immigrants a year, will grow to nearly 400 million at mid-century from 283 million today, it said.

Europe, in contrast, will start seeing a decline as early as 2003 without migration. Ukraine's population is projected to drop by nearly 40 percent by 2050, Russia's by 28 percent, Italy's by a quarter.

Roughly 20 years ago!

The Global 2000 Report to the President

*In which direction—beneficent or malign—
are the global trends going for the environment,
natural resources, and population?*

Projected 6.35 Billion
UN reported 6.1 Billion (not a bad projection)

In his 1977 environmental message to Congress, President Carter directed the Council on Environmental Quality and the Department of State, working in cooperation with other agencies, to make a study of the probable changes in the world's population, natural resources, and environment through the end of the century.

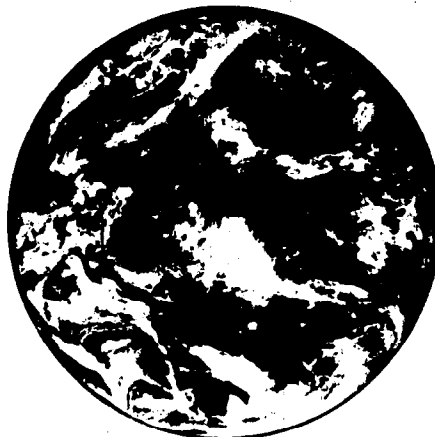
This was the beginning of what was a three-year effort to look at these issues and resulted in a massive three-volume publication that has been translated into many languages and sold half a million copies. It was the first time the U.S. government studied natural resources, population, and environment from a long-term global perspective and attempted to make connections among them.

The conclusions of the study are summarized in the following two paragraphs:

"If present trends continue, the world at 2000 will be more crowded, more polluted, less stable ecologically, and more vulnerable to disruption than the world we live in now. Serious stresses involving population, resources, and environment are clearly visible ahead. Despite greater material output, the world's people will be poorer in many ways than they are today.

"For hundreds of millions of the desperately poor, the outlook for food and other necessities of life will be no better. For many, it will be worse. Barring revolutionary advances in technology, life for most people on earth will be more precarious in 2000 than it is now—unless the nations of the world act decisively to alter current trends."

These statements, strong as they



are, have generated much controversy. At the January meeting of the American Association for the Advancement of Science (AAAS), four sessions were devoted to the Global 2000 Report. Several of the authors gave updates on what had been learned in certain areas since the report was written. In one session, criticisms were made of the report and of its implications, and one panel considered the effects this report should have on education. In some ways the debate between those who essentially agree with the report and those who disagree is similar to the age-old debate between doomsday prophets and "cornucopians," and goes back to Malthus and probably beyond.

Population

In the section on population, as in most topics of the Global 2000 Report, high, medium, and slow growth projections are made. All three predict that if present trends continue, the increase in the world population will be of unprecedented magnitude, and the world will gain many more people in

the next 25 years (1.88–2.22 billion) than it acquired in the last quarter century (1.56 billion). The medium growth projection forecasts that the world's population will grow from 4 billion in 1975 to 6.35 billion in 2000, an increase of more than 50%, while the rate of growth will decline only marginally from 1.8–1.7% per year. The poorest countries will experience 90% of this growth and by the year 2000 will have 78–80% of the world's population compared to 72% in 1975.

Samuel Baum of the U.S. Census Bureau, one of the original authors of the Global Report who spoke at the AAAS meeting, said there is no reason to expect that the problems projected in the report will be altered. He also said that since 1977, when the projections were prepared, many countries have taken censuses or released new data on fertility and mortality. The latest census figures have changed the predictions for some individual areas. For example, Africa would grow somewhat faster and Latin America somewhat slower; but the world population is still predicted to reach the same figure as in the Global Report.

Per capita income

The Gross National Product (GNP), which represents the total goods and services available to a society, is also discussed in the Global 2000 Report. GNP per capita is expected to increase by about a third. In some areas such as in the great populous nations of south Asia—Pakistan, India, and Bangladesh—little or no growth in per capita GNP is projected, while in some developing countries, especially in Latin America, the GNP

1982

per capita is expected to rise substantially. The large gap that already exists between the rich and poor nations will widen. The authors of the report caution, however, that projecting GNP is extremely difficult because it is dependent on so many variables. They say that the GNP data are particularly subject to error for the less developed countries because the contributions of the traditional sector cannot be accurately represented.

Food supply

If food were distributed uniformly, the world would probably be able to feed itself adequately in the year 2000. The Global Report forecasts a 90% increase in total food production for the 1970-2000 period, which translates into a 10-15% per capita rise. However, the bulk of the increase will probably go to countries that already have relatively high per capita consumption. The real price of food is projected to rise 30-115% over 1969-1971 prices, and in most cases food will go only to those individuals who can afford to pay for it or grow it themselves. The per capita consumption of food in South Asia, the Middle East, and the less developed countries (LDCs) of Africa is expected to improve little, if not actually decline below present inadequate levels. The World Bank estimates that because of rapid population growth, the number of malnourished persons in LDCs could increase from the current figure (400-600 million) to as many as 1300 million by the year 2000. The Global Report also states that in 2000, each arable hectare will have to support 4.0 persons instead of the current 2.6 persons (first half of 1970), and this will be accomplished through the increased use of fossil fuels, irrigation, and pesticides.

At the AAAS meeting, another of the original authors of the Global Report, Patrick M. O'Brien of the U.S. Department of Agriculture said that appreciably more of the world's resources will have to be used, and more extensively, to meet demand in 2000. In other words, additional land, water, fuel, and fertilizer will have to be devoted to food production. He also pointed out that trends since 1978 had changed sufficiently to suggest somewhat slower growth in the demand for food than expected and smaller per capita gains, but that recent developments tended to "support the general themes highlighted in the chapter" on food and agriculture.

Throughout history, there have been hunger and malnutrition somewhere in the world. However, as National

Academy of Sciences past President Phillip Handler observed: "The character of malnutrition has changed markedly in the last 40-50 years. The classical deficiency diseases—beriberi, scurvy, pellagra, rickets, sprue—have almost disappeared Instead, there is marasmus and kwashiorkor, both forms of general protein calorie insufficiency and iron deficiency anemia Malnutrition now reflects lack of food, not lack of scientific understanding." It is interesting to note that more people are malnourished today than the total population of the earth prior to about 1650.

Another factor that will make it difficult to feed the population of the year 2000 is that it will be a somewhat older population than that of today. As a population ages, the food requirements increase sharply. Also higher incomes in some parts of the world will cause eating habits to shift to a more diversified diet—from one of starches and cereals to one that includes meat* and other animal products. This kind of diet is more expensive and requires a larger amount of grain to sustain it. It is expected that many parts of the world will increase their dependence on the U.S. as a source of supply.

Environmental aspects

The Global Report states that the race to provide food for a rapidly growing world population will have, and already is having, harmful effects on the environment. Improper farming practices are increasing erosion and depleting the nutrients of topsoils. In summary, this report noted: "Evidence is accumulating that agricultural and grazing lands in parts of Africa, Asia, the Near East, and Latin America are already under such heavy stress that they simply cannot be expected to retain their present productivity through another two decades of intensifying human and animal population pressure." In LDCs there has been a great increase in the number of free-ranging animals; this has led to overgrazing, one of the leading causes of desertification. It is already a serious problem in Rajasthan, India, where sharp increases in the amount of land under cultivation have reduced available pasture land.

Even in the U.S., soil erosion is a current problem, although it has not resulted in a decline in overall productivity. In 1975 soil losses on U.S. crop land amounted to almost 3 billion tons, an average of about 9 tons per acre, according to the Department of Agriculture Soil Conservation Service. It has been estimated that soil losses must be cut in half if crop production

is to be sustained indefinitely.

In order to increase food production in LDCs by the year 2000, much greater use of pesticides will be needed. The other more modern and more costly methods of integrated pest management (the use of natural enemies, crop rotation, sterilization, and hormones to eradicate pests) will probably be too expensive for these countries. However, the heavy use of pesticides always results in the development of pesticide-resistant pests. Consequently, these are expected to cause considerable problems, especially because the world is expected to rely more and more on monocultures (single species), which means that an entire crop being grown in many different countries could become vulnerable to a single resistant pest.

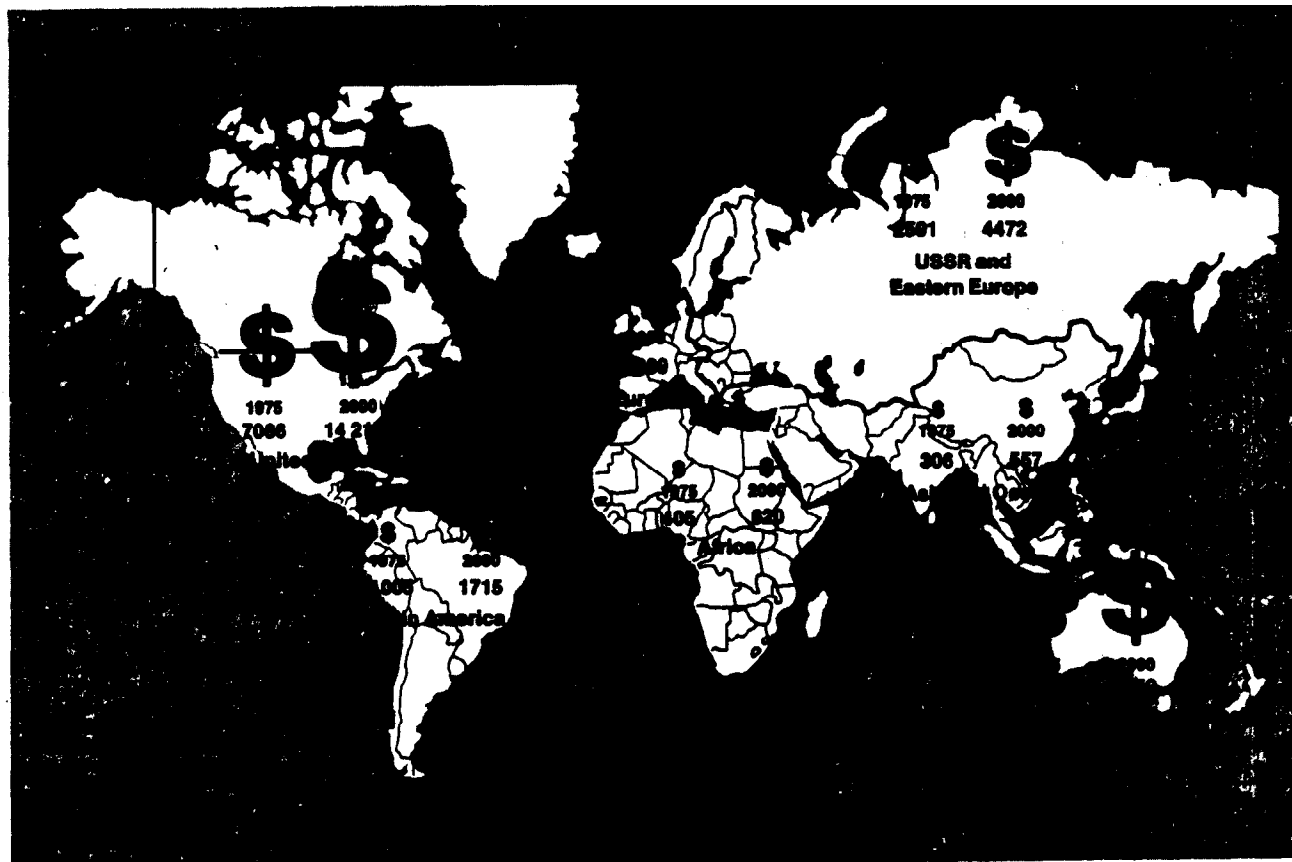
Irrigation will also have to be used much more extensively by 2000 if food production goes up as expected. By 1990, the irrigated area of the world is projected to rise from 223 million to 273 million hectares. It is estimated that about half of all the irrigated lands of the world have already been damaged by salinization, alkalization, and water logging. Damaged land can often be repaired; but the repair is expensive, and much of the injury has occurred in LDCs—countries which can least afford to remedy it. In Pakistan, for example, out of a total of 15 million hectares of irrigated land, about 11 million suffer from salinity, water logging, or both. Soil degradation from irrigation is expected to continue in many areas unless irrigation practices are changed.

Deforestation

One of the most serious problems that has resulted from the effort to expand crop growing areas has been deforestation. It has also been caused by logging operations and the building of highways when forests are cut down along the roads. However, in tropical areas where forests are being cut at a rapid pace, logging and farming usually go hand in hand. Loggers take out the large trees and are followed by farmers who burn the rest of the vegetation and begin to grow crops. If there is only sparse population in the area and no farmers follow the logging operation, reforestation is usually left to chance.

One of the authors of the Global Report, Bruce Ross-Sheriff of the Office of Technology Assessment, said at the AAAS meeting that there is controversy about the exact rate of deforestation, but no disagreement about the severity of the tropical forest resource problem. This report states:

*World's ~~with~~ livestock based protein is subject to rapid upset: hoof and mouth, "mad cow", tuberculosis, anthrax, tularemia



"Twenty-two years ago, forests covered over one-fourth of the world's land surface. Now forests cover one-fifth. Twenty-two years from now, in the year 2000, forests are expected to have been reduced to one-sixth of the land area." This statement may be somewhat exaggerated. A 1981 Food and Agricultural Organization (FAO) publication states that the tropical deforestation rate in Latin America is 0.64%, 0.61% in tropical Africa, and 0.60% in tropical Asia, which means that tropical deforestation is going on at about half the rate indicated in the Global Report.

Even if these FAO rates sound rather low, they do not mean that rapid deforestation is not taking place in certain countries. In Haiti, for example, only 9% of the original forests remain. Thailand has lost forests so rapidly that even the most optimistic estimates of the rate of destruction offer no hope of significant forest stands beyond 1993. For the countries of The Ivory Coast and Nigeria on the west coast of Africa, the situation is also serious. More than 70% of the forest area The Ivory Coast had at the beginning of the century has already been cleared. In Central Africa the situation is not alarming, except for Zaire and Cameroon, and in Eastern Africa deforestation is severe only in Madagascar. Nearly two-thirds of the

original area of tropical moist forest has already been converted to other purposes in India, Sri Lanka, and Burma.

Another study points out the seriousness of the tropical forest problem. A 1980 National Academy of Sciences report states that an area of tropical lowland forest about the size of Delaware is permanently converted to other forms each week, and an area about the size of Great Britain every year. This report goes on to say that "no more than scattered remnants of undisturbed tropical lowland forest are likely to survive into the 21st century," chiefly in western Brazilian Amazonia and Central Africa.

The creation of barren land

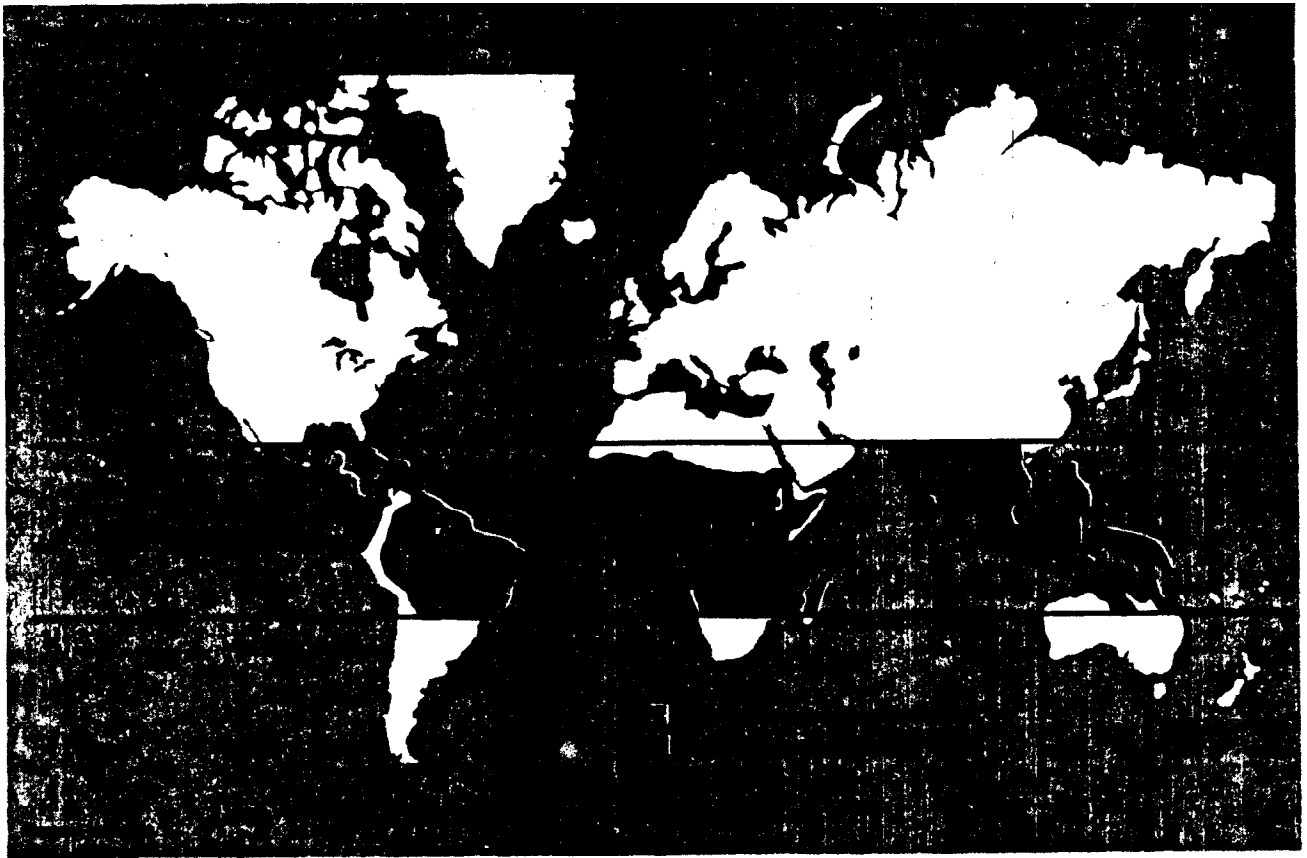
If extensive areas of tropical forest are converted to crop land on a sustainable basis, then deforestation might cause species extinctions and timber losses, but allow food production to be permanently expanded. Some areas, such as parts of the Amazon basin, can be and are being used for modern agriculture with appropriate soil technology. Much tropical forest land, however, is not suitable for raising crops, especially not on a continuous basis.

In many tropical forests, most plant nutrients are held in the diverse flora of the forest itself. If the forest is

standing, dying plants fall and decompose and the enormous mass of vegetation quickly recaptures the nutrients. If the forest is cut, burned over, and planted with crops, the nutrients are quickly washed off or deeply into the soil by the heavy rains and out into the streams and rivers. Many of these forest soils can maintain crops for no more than two or three years at a time, and no system is now in use that will sustain their productivity. After two or three years of cultivation, tropical forest soils often lose their ability to support crops or forest. If the land is allowed to lie fallow for about a decade while a secondary forest grows back, the species composition is often different and biological diversity much more limited.

In some tropical forest areas, a shift and burn method of agriculture has been practiced for centuries. After clearing, the land is burned, and crops are grown for a year or two. Then the land is allowed to lie fallow for about a decade while a degraded forest develops. After this the whole process is repeated. With this method, crops can be grown. In recent years, however, farmers have shortened the fallow periods in many areas because the populations have expanded so rapidly. The result has often been barren land.

In addition, the environmental effects of deforestation in tropical areas



are flooding, increased erosion, decreased water supplies, and sometimes drought. The loss of forest may also increase temperatures. According to the Global Report: "When the forest is razed, the heat that has fueled the evaporation-transpiration process instead raises the air temperature, usually to the detriment of seed germination, plant survival, . . . and human comfort." In addition, the loss of forest can cause an increase in atmospheric dust that some climatologists believe can prevent moist air from rising and inhibit precipitation.

Loss of species

Probably the most serious environmental effect of deforestation in tropical areas is an increased rate of species extinction (see *ES&T*, Vol. 16, No. 2, 1982, p. 94A). The Global Report states that "the rain forest areas modified by deforestation can be expected, with few exceptions, to include a negligible number of the species that were present in the virgin forests." Many tropical forests contain species that not only do not exist outside of these forests, but are unique to that particular area. Madagascar's forests, for example, contain species found nowhere else, which represent a museum of the cretaceous and paleocene biota of Africa. A majority of tropical forest species can exist only in a pri-

mary forest, and they regenerate very poorly. Tropical moist forests are believed to be the most complex and perhaps the most fragile ecosystems in nature.

If deforestation continues at the present rate, many species will be lost and a large portion of those lost will never have been described or catalogued. According to a recent NAS report, about two-thirds of most species of organisms exist in the tropics and these number about 3 million. Only about one-sixth of these are known to science at the present time. The report goes on to say that "it is not unrealistic to suppose that, within the next two decades, as many as a million species of plants and animals could disappear in the tropical forests."

There are some signs that efforts to hinder deforestation will increase in the future. At the recent AAAS meeting, Ross-Sheriff pointed out that since 1978 international development agencies began to turn from industrial forestry to agroforestry. For example, AID "increased its budget for vegetative-cover activities from \$1.8 million in fiscal year 1978 to \$25 million in fiscal year 1981." The World Bank and the U.N., among others, are likewise "expanding agroforestry work."

Thailand has taken strong measures to stop its cutting in national forests. However, when farmers and loggers

are remote from the seats of government, it is not known whether LDC authorities will have sufficient control to keep them from destroying the forests. Ross-Sheriff pointed out that "there is no reason to think that the Global Report's best-case scenario [for deforestation] can be achieved."

Temperate deforestation has not been as rapid as tropical deforestation. The temperate forests in some countries have probably expanded recently. However, the U.S. forests have changed significantly in the last few years. Many acres of natural hardwood forest have been converted into rapidly growing forest plantations, a type of crop land.

The Global 2000 Report discusses several other subjects such as water supplies, energy supplies, fisheries, and nonfuel minerals. The environmental effects of the projections are also covered. There is no area in which serious problems are not foreseen.

Assessment

The AAAS session criticizing the Global Report offered a wide variety of observations. Several scientists who were not authors of the original report, such as Julian Simon and S. Fred Singer, took issue with certain data reported. Many criticisms were made on the basis of the theory that if trends have been improving in certain areas

over the last 200 years, these developments will continue. Most of the trends cited concerned improvements in life within the U.S., such as longer life expectancies, declining death rates, decreases in the number of sick days in industry, growth in the amount of corn produced per acre. The observations presented may be true, but most of them are not global trends, and many are unrelated to the material presented in the Global Report. One panelist stated that there was no reason to believe that the earth did not have the capacity to support tens of billions of people. Garrett Hardin, author of "Tragedy of the Commons," pointed out that the trends of the past 200 years are not nearly as important as the trends of the past 25 years and that what we see taking place before our eyes is even more important. The basic conflict expressed at the AAAS meeting seemed to be between those who believe the earth has nearly unlimited resources to support a continually expanding number of people, and those who think the resources are limited and that we have almost exhausted the planet's capacity to support life in a satisfactory way.

To those who say that past trends in this country indicate what the world's future will be, we might compare the earth to a ship sailing in a foggy sea with poor navigational instruments. The trip might seem good for centuries and many trends could seem positive; but if cliffs cannot be clearly seen, eventually and quite suddenly the ship might collide with them. The question is whether we as a nation or world have radar that is accurate enough to detect dangers around us and whether we will see them in time and have the courage and conviction to avert disaster.

—Bette Hileman

Additional reading

"Research Priorities in Tropical Biology"; National Research Council, National Academy of Sciences; Washington, 1980.

"Global Future: Time to Act," Report to the President on Global Resources, Environment, and Population, The Council on Environmental Quality and the U.S. Department of State, January 1981.

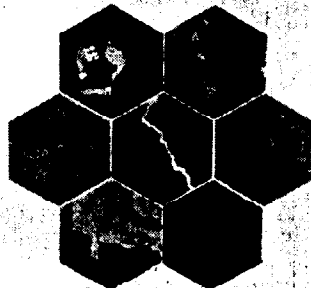
"The World's Tropical Forests: A Policy, Strategy, and Program for the United States," Report to the President by a U.S. Interagency Task Force on Tropical Forests, Department of State, May 1980.

"Conversion of Tropical Moist Forests"; National Academy of Sciences: Washington, April 1980.

"The Global 2000 Report to the President," Council on Environmental Quality and the Department of State: Washington, 1980; Vols. 1, 2, and 3.

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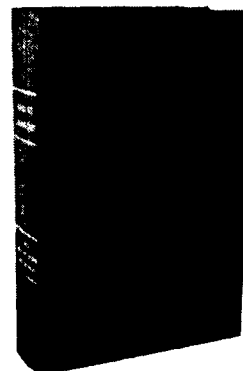
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Global 2000 Revised rewrites Global 2000 conclusion

Global 2000 Report (from letter of transmittal): Our conclusions, summarized in the pages that follow, are disturbing. They indicate the potential for global problems of alarming proportions by the year 2000. Environmental, resource, and population stresses are intensifying and will increasingly determine the quality of human life on our planet. These stresses are already severe enough to deny many millions of people basic needs for food, shelter, health, and jobs, or any hope for betterment. At the same time, the Earth's carrying capacity—the ability of biological systems to provide resources for human needs—is eroding. The trends reflected in the Global 2000 study suggest strongly a progressive degradation and impoverishment of the Earth's natural resource base.

Global 2000 Revised: Our conclusions are reassuring, though not grounds for complacency. Global problems due to physical conditions (as distinguished

from those caused by institutional and political conditions) are always possible, but are likely to be less pressing in the future than in the past. Environmental, resource, and population stresses are diminishing, and with the passage of time will have less influence than now upon the quality of human life on our planet. These stresses in the past have always caused many people to suffer from lack of food, shelter, health, and jobs, but the trend is toward less rather than more of such suffering. Especially important and noteworthy is the dramatic trend toward longer and healthier life throughout all the world. Because of increases in knowledge, the Earth's "carrying capacity" has been increasing throughout the decades and centuries and millenia to such an extent that the term "carrying capacity" has by now no useful meaning. These trends strongly suggest a progressive improvement and enrichment of the Earth's natural resource base, and of mankind's lot on Earth.