Policy Analysis

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Executive Summary

The recent Earth Summit, the United Nations Conference on Environment and Development (UNCED), in Rio de Janeiro was to have established an ambitious environmental agenda for the 21st century. The conference addressed virtually every field of human endeavor: energy, industry, water and land use, agriculture, human health, and transportation, among others. An international congregation of tens of thousands of bureaucrats, environmentalists, technocrats, planners, and others arrived in Rio to guide humanity on its course toward the brave new world defined by Agenda 21, the Rio Declaration, the Conventions on Climate Change and Biological Diversity, and the Forest Principles.

The principal theme for UNCED was "sustainable development," a concept popularized by the report of the World Commission on Environment and Development. That report, entitled Our Common Future, was presented to the United Nations in 1987 by commission chairman Gro Harlem Brundtland, the Labor prime minister of Norway.

Our Common Future was compiled in response to a 1983 request of the UN General Assembly for "a global agenda for change." Heavily influenced by former West German chancellor Willy Brandt's North-South Report, the commission called for restructuring mankind's future so that economic growth would be "based on policies that sustain but expand the environmental resource base."[1]

"Sustainable development" means different things to different people. Its definition is intentionally vague to increase the possibility of compromise on thorny issues on which reasonable people may differ. To those inclined toward balancing economic and environmental goals--as are the authors of this study--"development" implies economic growth, and "sustainable" implies full consideration of environmental factors. It is becoming abundantly clear, however, that to others the term implies virtually no additional economic development.[2] The latter position is based on the argument--made with great emotion but insufficient facts and analysis--that the current path of development is clearly unsustainable because the planet is about to choke on humanity's wastes and there is not enough land to meet everyone's demands. Even though that faction, inherently suspicious of technological change and economic growth, was unable to obtain all that it wanted, it is today much closer to its goal as laid out explicitly in the early drafts of the Agenda 21 documents.

The draft Agenda 21 documents specified various measures that nations "should" undertake. Ultimately, the conference shied away from that heavy-handed approach and decreed those measures to be optional. If acted upon faithfully, many of those measures would impose national planning on virtually every economic sector, regulate almost all human activity, and subordinate all social and economic goals to environmental goals. Thus, while calling for a massive transfer of wealth and technology from developed to developing nations, the recommended measures would deny all nations the means of creating more technology and wealth by putting in place legal and institutional frameworks that would be incompatible with either technological progress or economic growth. Proponents of those measures, in part because of their refusal to balance environmental and socioeconomic goals, would needlessly reduce agricultural productivity in the name of sustainability--even as they lament that the world has too many people to feed and that agriculture uses too much land and denudes forests, thereby threatening species and reducing biodiversity. Such measures, in addition to being poor social and economic policy, would be counterproductive; they would cause more environmental harm than good, and they might even bring about the very catastrophe environmentalists strive to avert.

In particular, the Convention on Biological Diversity, which the United States rightly refused to sign, does not even address the single most important reason for the loss of biological diversity and deforestation: the loss of habitat and land conversion to meet fundamental human needs for food, clothing, and shelter. Moveover, the convention would reduce the incentives to research and develop the very technologies that would--if anything could--help meet the competing demands made on land by human beings and other species.

Using as an example the historical increase in U.S. agricultural productivity, this study will show that--but for technological progress--all our forestlands and croplands, including those that would have been only marginally productive, would have had to have been plowed to produce the quantities of food we produce today. The accompanying wholesale destruction of forests and other natural habitats and the reduction of biodiversity would have resulted in environmental problems that would have dwarfed those we face today and matched environmentalists' worst nightmares.

The only way to feed, clothe, and shelter the greater world population that the future will inevitably bring--while limiting deforestation and loss of biodiversity and carbon dioxide sinks--is to increase, in an environmentally sound manner, the productivity of all activities that use land.[3] Such increases are possible only within a legal, economic, and institutional framework that relies on free markets, fosters decentralized decisionmaking, respects individual property rights, and rewards entrepreneurship. Such an approach is the best hope for a world facing severe pressure on its land base, yet it has been noticeably absent from recent, much-publicized strategies that purport to lead us to sustainable development, conserve biological diversity, and combat global deforestation.

Technological Progress and Agricultural Land Use in the 20th Century

Technological change or progress, as used here, includes all the changes, on or off the farm, that have af- fected the economics of the supply of, demand for, and utilization of agricultural commodities. Included are changes in output due to changes in input; the introduction of new products and processes that have created new demands or reduced (or eliminated) demand for existing products and processes; and changes in lifestyles and tastes, themselves often the product of technological advances, that have affected demand for agricultural products.[4] Thus, technological change includes changes in machinery, seed varieties, fertilizers, pesticides, and other inputs; in management practices; and even in the land base. It also includes substitution of the internal combustion engine and electrical power for human, animal, and steam power as well as new and improved consumer products, derived from petroleum and other mineral resources, that substitute--to varying extents--for agricultural commodities used previously (e.g., synthetic fibers for cotton, flax, fur, and feathers). Anything that affects the market penetration of existing technology also constitutes technological change. In this study the sum of all such changes is considered technological change. Under that definition, technology that is available but has not been adopted for economic or institutional reasons does not constitute technological change.

To estimate how technological progress in the 20th century has influenced the amount of land used for agricultural purposes, one should ideally examine data from the 19th century, if not before. Because of data limitations, however, we have made calculations from 1910 data.

In 1910, 200 million acres were harvested to feed and clothe the U.S. population of 92.0 million.[5] In addition, 88 million acres were harvested to feed 27.5 million horses and mules (Table 1).[6] (Had there not already been 468,500 motor vehicles in 1910, more land would undoubtedly have been needed for domestic purposes.) Twenty-four million of the 27.5 million horses and mules were on farms. Historical estimates of the amount of land required to feed horses and mules assume that nonfarm animals need one-third more feed than farm animals.[7] Therefore, we estimate that 277 million acres were needed for all domestic purposes (including feed for horses and mules used to work the 200 million acres as well as for all nonfarm purposes), and 48 million acres were needed to produce crops for export.[8]

In 1988 only 176 million acres of cropland were harvested to meet all the domestic needs of 246 million people. Had technology, its market penetration, and the U.S. standard of living been frozen at their 1910 levels, we would have needed to harvest 741 million acres to meet domestic needs, an increase of 565 million equally productive acres.

In 1988 about 40.7 percent (or 121 million acres) of U.S. cropland were harvested for export. If the average productivity of land (for purposes other than producing feed for horses and mules) had been frozen at the 1910 level, we would have needed 368 million acres to produce those exports. We also would have needed an additional 113 million acres to feed the horses and mules necessary to work the 368 million additional acres. Thus, if technology (and its market penetration) had been frozen at 1910 levels, in 1988 we would have needed to harvest about 1,222 million acres, rather than the 297 million acres actually used, to meet our domestic needs and produce the same amount for export.[9]

Table 1
U.S. Population and Acreage Harvested for Crops (1910-88)

Year	Population (Millions)	Domestic Use	Feed for Horses/Mules	Exports	Total(a)
1910	92.0	200	88	37	325
1920	105.7	210	90	60	360
1930	122.8	265	65	39	369
1940	131.7	290	43	8	341
1950	150.7	276	19	50	345
1960	179.3	255	5	64	324
1970	203.3	221	NA(b)	72	293
1980	226.5	215	NA	137	352
1988(c)	246.3	176	NA	121	297

Sources: Statistical Abstract of the United States, 1990 (Washington: U.S. Department of Commerce, 1990), Tables 1 and 2, p. 7; and Historical Statistics, Colonial Times to 1970 (Washington: U.S. Department of Commerce, 1975), Series K496-501, p. 510.
(a)In addition, about 10 percent more land is cultivated summer fallow.
(b)NA = Not available. Data for this category were merged with the figures for domestic use. cPreliminary data.

To put the enormous requirement of 1,222 million acres into perspective, consider the fact that the total U.S. land area, including Alaska, is 2,271 million acres. Thus, over 54 percent of the entire U.S. land mass would have had to have been put to plow. As noted below, even that is a conservative estimate. Clearly, absent technological change, America would be in dire straits.

Table 2
Projected Acreage Necessary for Crop Production in 1988 If Technology Had Been Frozen at 1910 Level

Use	
Domestic food production	535
Horses/mules for domestic production and other uses	206

Exports	368
Horses/mules for export products	113
Total acres needed under a technology freeze	1,222
Acres actually harvested in 1988	297
Minimum additional acres required for 1988 production with no technological change from 1910 levels	925

Note: calculations ignore land that is fallow or in cover crops. Generally, that amounts to about 10 percent of harvested land.

Thanks to technological change, we use at least 925 million fewer acres for crop production today than we would have without such change (Table 2). The preceding calculation assumes that the additional land would be as productive as the first 297 million acres--a heroic assumption at best. Although it is possible to arrive at different estimates of the amount of additional land that would have been necessaryby varying the definition of what constitutes technological change, the number of acres is so large that the basic lessons and policy conclusions outlined below would not be affected.

Because of overplanting and inefficient use of land for agriculture due to federal farm programs and subsidies, we produced more food than was necessary on the 297 million acres harvested in 1988. Any reduction in agricultural land use due to elimination of subsidies, however, would obviously be small compared with the 925 million acres not needed because of technological progress. Moreover, it should be noted that not all subsidies have resulted in more land's being used for agriculture--some subsidies have merely intensified agricultural production from land that would have been farmed under any circumstances.

Reducing U.S. agricultural subsidies might not, however, result in a net reduction in agricultural land use worldwide. It might result in greater (or more intensive) land use in other countries. To the extent that reduced subsidies might increase the pressure on land in developing countries or in areas of greater biological diversity, it might actually make preservation of forests, other natural habitats, and biological diversity more difficult. In fact, if reducing such subsidies resulted in more land use in, say, Indonesia or Brazil, the net effect on preservation might be adverse. Clearly, a global analysis of the net effect of reducing subsidies in the United States (or other developed nations) is necessary to determine whether such reductions would result in a net benefit in terms of preservation goals. Nevertheless, it should be noted that elimination of such subsidies makes economic sense, regardless of whether it necessarily has a net conservation benefit.

Furthermore, gains in agricultural productivity have occurred even as some of the best and most productive farmlands have been lost to urban sprawl, transportation infrastructure, and other uses associated with development. Were it not for technological change, the demand for certain agricultural commodities would need to be higher than it is today to maintain the same standard of living. For instance, were it not for synthetic fabrics, we would need to cultivate more cotton and flax and to rely more on animal hides and pelts. Including those two sets of changes in our analysis would only strengthen our major conclusion that it is critically important to stimulate technological progress and agricultural productivity.

The principal reasons we are able to meet our expanded needs for food and other agricultural commodities for the domestic and foreign market with as much, or less, land are the various technological and management changes that have occurred in each step of crop production and distribution, as well as in the supply of and demand for agricultural products. In particular:

The internal combustion engine eliminated the need for horses and mules to provide transportation and to power agricultural machinery. If the horse and mule population had expanded in proportion to the human population, we would have needed 319 million additional acres just to produce feed for our horses and mules-- more land than we currently harvest to feed our entire human population, as well as millions abroad. Thus, it would seem that horses and mules would be less "sustainable," even though they employ "renewable" fuels, than the internal combustion engine, which relies on "nonrenewable" fuels. (In 1910 there were about four people for each horse or mule. If it were possible to freeze technology at 1910 levels and still improve the general standard of living, it would be reasonable to expect that the number of horses and mules per capita would increase. That, in turn, would increase the amount of land needed for feed.)

The widespread availability and use of agricultural fertilizers and pesticides and new cultivars have led to more intense land use and higher yields of quality produce.

Additional irrigation capability; conversion of wetlands to highly productive farmlands through tile, levee, and drainage systems; and the development of more productive livestock and livestock confinement systems have increased yields relative to inputs of land and labor.

Better management practices have increased productivity while reducing soil loss and improving the efficiency of water use; for example, more powerful tractors have allowed the use of deep tillage tools, which contribute to increased soil conservation.

The advent of refrigeration in the home and in stores and advances in transportation have led to less spoilage and have reduced the need for deliberate over-production.

New and efficient processing technologies have resulted in better utilization of raw commodities (both agricultural and mineral) in the consumer markets for food, feed, and fiber products.

An efficient infrastructure has developed to distribute and store agricultural products.

Each of those changes undoubtedly has had some detrimental effects on the environment. For example, agricultural fertilizers and pesticides pollute waters, and the draining of wetlands has contributed to loss of habitat for some species. Several recent publications address those issues.[10] Instead of dealing with those familiar themes, the remainder of this paper will address what is often ignored or forgotten: the beneficial effects of technological change on the nation's land resources and, in particular, on forestlands, other natural habitats, and biological diversity.

Beneficial Effects of Technological Change in Agriculture on Land Utilization

Clearly, technological change has enabled us to feed much larger domestic populations and to provide them with better nutrition. It has also helped the United States to supplement the rest of the world's food supplies. In addi tion, as the preceding calculations indicate, a major benefit of technological change has been the dramatic reduction in the amount of land that would otherwise have been converted to agriculture.

As projected above, at least 925 million more acres would have needed to have been harvested in 1988 if technology had been frozen at 1910 levels. To put that into perspective, an additional 925 million acres corresponds to

> over 11 times the total acreage currently managed under the National Park system (including Alaska),
>
> over four times the total acreage currently in the National Forest system (including Alaska),
>
> about three times the acreage of all cropland now harvested in the United States,
>
> over four times the total acreage of wetlands in the conterminous United States in the 18th century and eight times the current area of wetlands, and
>
> over 180 times the area purchased by the federal government since 1965 using the Land and Water Conservation Fund at a cumulative cost of over $17 billion (in 1991 dollars). In the absence of technological change, increases in relative land prices would have reduced the amount of land that could have been purchased with the same level of funding.

Table 3 provides information on land use in the United States (excluding Alaska and the District of Columbia). Figure 1 shows how much land would have been needed for harvest in 1988 if technology had been frozen at 1910 levels, as well as the total amount of cropland and forestland.[11] The minimum of 1,222 million acres that would have needed to have been harvested would have

> exceeded total cropland and forestland in the United States (excluding Alaska) by 15 percent (those lands occupy 1,066 million acres) and
>
> required that at least 60 percent of the U.S. land area (excluding Alaska) be harvested for crops.

Table 3
Land Use in the United States, Excluding Alaska and the District of Columbia, 1987

Cropland	
Used for crops(a)	331
Idle	68
Used only for pasture	65
Subtotal (cropland)	464
Forestland(b)	559
National Park system, Refuges, and Wilderness Areas	64
Urban areas	57
Transportation	26
Grassland pasture(c)	590
Special-use areas(d)	45
Other land	93
Total	1,900

Sources: Agricultural Statistics, 1991 (Washington: U.S. Department of Agriculture, 1991), Table 533, p. 357; Environmental Quality, 1991 (Washington: Council on Environmental Quality, 1991), Tables 45-46, pp. 291-92; and statistics from National Park Service, Fish and Wildlife Service, and Bureau of Land Management. Note: Numbers do not add due to rounding.
(a)Cropland harvested, crop failure, and cultivated summer fallow.
(b)Excludes 43 million acres, duplicated in parks, refuges, wilderness areas, and other special uses of land.
(c)Grassland and other nonforest pasture and range.
(d)Includes federal and state areas used primarily for recreation and wildlife purposes (except National Parks, Refuges, and Wilderness Areas), military areas, farmsteads, and farm roads and lanes.

Although firm estimates of the amount of arable land in the United States are not available, one often-quoted estimate, based on the U.S. Department of Agriculture's National Agricultural Lands Survey, pegs it at 540 million acres.[12] Clearly, there is not enough suitable land in the United States to have produced the same amount of crops actually grown in 1988 if technology had been frozen at 1910 levels. Moreover, as noted previously, the calculation of 1,222 million acres assumes that the last 925 million acres of harvested land would be as productive as the first 297 million acres. It also does not allow for land that may be idled or kept in cover crops. Thus, in the absence of technological change, much more than 1,222 million acres would have needed to have been harvested--unless famine claimed a large share of the population.

Figure 1
Land Use In the United States (Excluding Alaska) In 1988 with and without increases in Agricultural
Type of Land Million Acres
Actually Harvested 297
Needed for Harvest if Agricultural Productivity Were Frozen at 1910 Levels 1,222

Total Forestland 602 (Cropland- 464)
Total Arable Land 504
Land Purchased Using Land & Water Conservation Fund, 1965-91 5
(Graph Omitted)

Land conversion of such massive proportions would mean that about the only areas left as National Parks, Wilderness Areas, or other reserved lands would be mountain peaks or virtual deserts unable to support any cultivation. The amount of forestland would also be reduced substantially, and the forest acreage left would be harvested more frequently. There would be even greater pressure to drain wetlands. On each of those counts, natural habitat and biological diversity would be the losers. Finally, such massive land conversion would almost surely result in higher net greenhouse gas emissions into the atmosphere.

Changes in Actual Area of Farmlands

So far we have considered only what might have happened had technology and agricultural productivity been frozen at 1910 levels. Let us now look at actual trends.

Table 4
Land Use in the United States, Excluding Alaska and Hawaii, 1910-69
(Millions of Acres)

Use	1910	1969
Cropland for crops	324	333
Idle cropland	23	51
Pasture and grazing(a)	1,084	886
Unpastured forestland and woodland	293	406
Other land(b)	179	221
Total	1,903	1,897
Population (in millions)	92	201

Source: Agricultural Statistics, 1976 (Washington: U.S. Department of Agriculture, 1976), Table 587, p. 420.
(a)Includes cropland used as pasture, pastured forest or woodland in farms, grazing land, and pastured forestland not in farms.
(b)Includes urban, industrial, farm and nonfarm roadways and residential areas, unused wastelands, parks, and wildlife refuges.

Table 4 shows that between 1910 and 1969 there was not much change in total cropland acreage, whether used for crops or left idle. Pasture and grazing land, however, declined from 1,084 million to 886 million acres, a decline of about 200 million acres; unpastured forestland and woodland increased from 293 million to 406 million acres. (Because data in the same format were not readily available after 1969, this precise analysis could not be extended to a more recent year.) A substantial portion of the decline in pasture and grazing lands was also manifested as a decline of land in farms. Land in farms (not all of which is cultivated or cultivable) peaked in 1950 at 1,161 million acres. By 1987 it had dropped by almost 200 million acres, to 964 million acres.[13] Thus, the land taken out of farms is more than twice all the land area currently used for urban and transportation purposes--83 million acres (see Table 3); less than half of the land that was freed was developed. As the data in Table 4 indicate, much of the 200 million acres freed nationally is now left to nature or managed as forestlands or woodlands.

Table 5
Changes in Cropland, 1949 to 1987, New England and Mid-Atlantic Regions (Thousands of Acres)

	1949			1987		
	Used for Crops(a)	Used for Pasture(b)	Total	Used for Crops(a)	Used for Pasture(b)	Total

Connecticut	369	450	819	167	40	207
Maine	1,186	877	2,063	490	87	577
Massachusetts	473	491	964	218	53	271
New Hampshire	349	545	894	116	31	147
Rhode Island	55	52	107	24	5	29
Vermont	937	1,704	2,641	467	188	655
New England	3,369	4,119	7,488	1,482	404	1,886
New Yor k	6,906	6,067	12,973	4,432	822	5,254
New Jersey	930	329	1,259	579	73	652
Pennsylvania	6,834	3,855	10,689	4,749	803	5,552

Source: Agricultural Statistics, 1953, Table 642, pp. 548-49; and Agricultural Statistics, 1990, Table 538, p. 359. aIncludes harvested, crop failure, fallow, and idle lands. bIncludes cropland used only for pasture.

The consequences of the reversion of land to nature as a result of the reduced need for farmland are quite apparent in some areas of the country. In New York, for example, there were 24 million acres of farmland in 1880; today there are about 8 million acres (i.e., a reduction of about two- thirds).[14] That reduction in farmland is also matched by reductions in cropland: between 1949 and 1987 cropland declined from 13.0 million acres to 5.3 million acres, or by about 59 percent (Table 5). Similar impressive reductions in farmland have been recorded throughout the Northeast: from 1880 to 1969, land in farms in that region was reduced from 68 million to 26 million acres, whereas in 1989 it stood at 23 million acres,[15] also a reduction of about two- thirds since 1880.[16] Between 1949 and 1987 cropland declined from 32.4 million acres to 13.3 million acres, or by 59 percent. Most of those lands reverted to nature or are managed as forestlands or woodlands; relatively little was built up. (The entire Northeast in 1987 had less than 10 million acres that were urbanized or used for transportation).[17] As a result, wildlife is more abundant and varied today than it was at the turn of the century, and some species are making a comeback.[18]

Discussion

During this century, technological progress has made it possible to limit U.S. land conversion to agricultural uses, thereby protecting natural habitats and biological diversity. That has been achieved by (1) greatly increasing the overall productivity of all agricultural activities (from planting to harvesting, processing, distribution, and storage); (2) making obsolete, due to the introduction of the internal combustion engine, the use of animals for transportation, industry, commerce, and agriculture; and (3) reducing the demand for certain agricultural commodities from what it otherwise might have been by producing economic substitutes from noncrop sources (e.g., synthetic fibers). A similar analysis done for the entire world would undoubtedly lead to similar conclusions.

Is Technological Progress Inevitable?

That technological progress occurred over the past century--enabling us to feed a much larger population a healthier diet, without significant total land conversion to agriculture--does not mean that it was inevitable; nor does it mean that we can necessarily expect similar progress in the future. Progress is not a foregone conclusion. In our own time, we have seen political, economic, and legal systems such as those of the former Soviet Union and other centrally planned economies stymie progress, not just in technology but in all spheres of human endeavor. Those societies, despite their high level of general and scientific education and access to technology, failed even to feed themselves adequately. They fell victims to

--centralized decisionmaking (i.e., the hubris that a group of people--because they were well intentioned, had common goals, and were among the best and the brightest a nation could offer--could indeed direct an entire economy along a well-chosen path);

--the failure to establish and respect individual property rights; and

--the failure to reward ordinary individuals for their investment of labor, capital, and management.

Going back further in history, the story of humankind is not one unbroken chain of ever-ascending accomplishments. The Roman Empire was not succeeded by an even more brilliant civilization, and other civilizations have reached their zeniths and then declined.

Clearly, progress is not preordained. The recent experience of the former Soviet Union and other centrally planned economies, for example, indicates that education, availability of information, and technology transfer are necessary but not sufficient conditions to sustain high-yield agriculture and a modern food supply system. The legal, economic, and political framework also has to be open to innovation and has to reward individuals for their endeavors.

How to Meet Future Demands for Agricultural and Forest Commodities While Conserving Forestlands

Over the next century, the world population is projected to more than double from the current 5 billion to between 11 billion and 15 billion. Moreover, it is hoped that the average economic well-being of that larger population will improve. Both factors would increase the demand for agricultural and forest commodities, as well as for land for livestock and settlements. If the population were to double and food production per capita were to increase by 0.8 percent per year, by 2050 food production would need to be 223 percent greater than it is today.[19] If the demand for forest products caused by improved economic circumstances were to increase by 2 percent per capita per year, by 2050--all else (including technology) being equal--the demand for forest commodities would increase by 550 percent.[20]

There simply is not enough productive land in the world to meet such increasing demands for food and forest products--unless there is continued technological progress. Such progress will be crucial to maintaining or improving the quality of life of all the societies of the world. The question, therefore, is not whether technological progress is inevitable, but rather, how do we ensure that it is? The primary issue surrounding deforestation and conserving biological diversity and carbon dioxide sinks is how to ensure that not all productive lands--including those that are marginal--are devoted to crops, forest products, grazing of livestock, and human settlements. How to manage productive lands that will not have been pressed into service to meet human demands, though important, is a secondary issue.

The continued opportunity for the societies of the world to benefit from technological change gives rise to the hope that standards of living and the quality of life can be maintained or improved. Improved economic conditions often go hand in hand with more stable population levels.

Conclusion and Recommendations

The foregoing discussion indicates that the key to conserving forests, other natural habitats, biological di versity, and terrestrial sinks of carbon dioxide is to improve the efficiency and productivity of all activities that use land while ensuring that those activities are environmentally sound. Those activities include agriculture, production of forest products (including fuel wood), grazing, and development of human settlements. Thus, a primary goal of a World Forestry Agreement or a Biodiversity Convention should be to recognize the need to increase, in an environmentally sound manner, the efficiency and productivity of land. Unfortunately, the recently negotiated Convention on Biological Diversity fails to address that issue and, as a result, is flawed and would be ineffective. Moreover, by increasing the hurdles to research and development of the very technology that would reduce, if not avoid, further habitat loss and land conversion, that convention would be counterproductive.

To meet the overarching goal of satisfying fundamental human needs for food, clothing, and shelter while also ensuring the conservation of biodiversity and forests, the following general principles should be adhered to:

--Political, economic, and legal institutions must be set up to reward individuals and innovators for their endeavors.

--Those institutions must encourage decentralized decisionmaking.

--Everyone involved in each link of the food and agricultural system should have an economic incentive to develop or use innovations, or both.

--Research and development of new, more efficient, and productive technologies and practices should be continued.

--Unnecessary and unfair barriers to the dissemination and adoption of innovations should be removed. Many environmental laws or regulations treat new polluting sources (or chemicals) more stringently than older sources (or chemicals). The "new source bias" discourages innovation and increases the lifespan of old and sometimes outmoded and more polluting technologies. Such bias is neither good economics nor, as this discussion indicates, good environmental policy.[21]

Specifically, we make the following recommendations.

--The U.S. Department of Agriculture, working with pertinent agencies, institutions, and groups, should identify and reduce barriers to the adoption of more productive techniques for agriculture, grazing, and forestry, including the use and acceptance of bio-engineered products such as bovine somatotropin. (BST, a growth hormone, can reduce the feed requirements for producing a pound of beef or a gallon of milk from beef and dairy cattle. Its use would, therefore, reduce the amount of land devoted to producing feed for livestock. Moreover, by reducing the number of animals necessary to produce a given quantity of beef or milk, BST could also help reduce emissions of methane--a potent greenhouse gas.) Barriers include legal and regulatory hurdles (e.g., permits and licenses for research, development, and general use of technology); lack of public acceptance; lack of information, infrastructure, or incentives for technology transfer (e.g., insufficient protection of property rights); and trade (and other) barriers of potential importing countries.

--Any analysis of (1) sustainable development, (2) environmental soundness, and (3) the benefits and costs of using a pesticide, fertilizer, or food preservative (including bioengineered products) should explicitly include--as a benefit--the reduced use of land and reduced destruction of habitat, as well as the enhance-resulting from that reduced use of land. Accordingly, documents, analyses, and actions subject to the National Environmental Policy Act and other legislation affecting farms or food processing, distribution, and storage should explicitly consider any changes in the productivity of activities that use land; their impact on the total area available for different land uses; and their potential effects on the preservation of forestlands, other habitats, and biological diversity.

--The United States should continue to support development of economic and political systems that emphasize free world trade, market-based production incentives, and individual opportunity to benefit from more efficient technology and management practices.

--The United States should also continue to aggressively espouse the elimination of all government programs and policies that lead to the inefficient use of land, including agricultural subsidies and trade barriers.

--Laws that restrict population density should be reviewed to evaluate their potential for contributing to net environmental deterioration. Such laws encour age sprawl, which in turn removes some of the more productive land from agriculture and increases the pressure to drain wetlands. Sprawl makes mass transit and other energy-saving practices (such as district heating) less viable. In many instances, governments have weighed in against higher population densities and have thus indirectly encouraged sprawl (and its attendant shortcomings), even as they decried the loss of agricultural land and wetlands to urbanization. Accordingly, documents, analyses, and actions subject to the National Environmental Policy Act should explicitly consider any changes in population densities, the impacts on the total area available for different land uses, and the potential effects on land conversion.

--Research intended to (1) improve the productivity of agriculture, forestry, and grazing and (2) develop new and efficient methods of meeting human needs for food, shelter, and clothing that are less dependent on land-based activities should be strengthened. To finance such additional research, the law governing the use of the Land and Water Conservation Fund could be amended appropriately.

--Finally, the president should issue an executive order that (1) notes the importance of increasing, in an environmentally sound manner, the productivity of all activities using land so that human needs for food security, clothing, forest products, and shelter can be met while conserving forests, other natural habitats, and biological diversity and slowing down the accumulation of greenhouse gases in the atmosphere and (2) directs all departments and agencies to review their authorizing laws, regulations, policies, programs, and actions and take appropriate measures to significantly reduce any resulting barriers to adoption, dissemination, and use of more productive technologies and land management practices in an environmentally sound manner.

Summary

Good stewardship requires that all resources--energy, land, and all other natural resources--be used as efficiently and productively as possible. It would be ironic if well-intentioned actions and programs to improve the environment by limiting agriculture inputs only aggravated the threats to forestlands, other natural habitats, biological diversity, and carbon dioxide sinks. Instead, we need to take a global view of the consequences of actions that affect the productivity of land and support a more comprehensive, careful, and objective analysis of the benefits and costs of such actions.

Some people currently advocate an end to technological advances in the belief that such changes most often have greater adverse consequences than benefits for society. Others advocate less intensive land use for agriculture in the hope that somehow the result will be less total environmental damage while farm income is maintained and needed products are provided. The preceding discussion of the potential effects of having stopped the clock on progress in 1910 should offer some insight on the wisdom of taking such actions now. More significant, such an examination indicates the wisdom of placing increased emphasis on supporting environmentally sound technological change and improvements in agricultural productivity as the key to ensuring that sufficient productive land remains in the future for purposes other than fulfilling human needs.

Finally, it should be noted that one consequence of low-input sustainable agriculture (LISA) is that more land would be devoted to crops than would be otherwise. The extra land used for agriculture will mean that much less for other species. What we need is not LISA, but HOSA--high- output sustainable agriculture--consistent with each farmer's maximizing his or her net income in a free-market environment. With equal emphasis on both the high output and the sustainability criteria, in some situations HOSA may resemble LISA, but not the other way around.

Notes

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[1] Our Common Future: The Report of the World Commission on the Environment and Development (Oxford and New York: Oxford University Press, 1987), p. 1.

[2] It is ironic to note in this context Norway's (and Brundtland's) dispute with the International Whaling Commission over whether to resume controlled harvesting of minke whales, a species that is neither threatened with nor in danger of extinction.

[3] This study is based on ideas broached in "Climate Change Effects on Fish, Wildlife and Other DOI Programs" in Coping with Climate Change, Proceedings of the Second North American Conference on Preparing for Climate Change, December 6- 8, 1988 (Washington: Climate Institute, 1988), pp. 273-81. That work was later incorporated into two 1989 reports of a U.S. Interagency Task Force, chaired by one of the authors, that dealt with the Intergovernmental Panel on Climate Change (IPCC) Work Group III's Resource Use and Management Subgroup. Those reports, entitled "Unmanaged Ecosystems- Biological Diversity: Adaptive Responses to Climate Change" and "Land Use Management: Adaptive Responses to Climate Change" were reflected in the IPCC Work Group III report, Climate Change: The IPCC Response Strategies (Washington: Island Press, 1991), chap. 6.

[4] Examples of products for which demand has changed due to technological change include eggs, red meat, poultry, and tropical vegetable oils. It can also be argued that without technological change, which has resulted in a better traveled population that is more open to new culinary experiences, many of the products we see on supermarket shelves (e.g., Mexican and Chinese foods) would not be available in their current quantities.

[5] Historical Statistics, Colonial Times to 1970 (Washington: U.S. Department of Commerce, 1975), p. 510.

[6] Agricultural Statistics, 1915 (Washington: U.S. Depart ment of Agriculture, 1915), p. 143; and Historical Statistics, Colonial Times to 1970, p. 510.

[7] Historical Statistics, Colonial Times to 1970, p. 503.

[8] In addition, 23 million acres were idle or in cover crops. For the purposes of this discussion, we ignore that acreage. Inclusion of such acreage would only strengthen the conclusions of this study.

[9] In addition, 31 million acres were cultivated summer fallow--an agricultural practice designed to conserve mois ture by not planting crops for a season to ensure that there is enough soil moisture to sustain a crop the following season. As indicated in note 8, we ignore that acreage.

[10] See, for example, Agriculture Policy, Consumers and the Environment: A Guide to the 1990 Farm Bill (Washington: Public Voice for Food and Health Policy, 1990).

[11] We have excluded Alaska from the calculations because, relative to the rest of the United States, its ability to produce crops based on 1910-vintage technology is virtually zero.

[12] S. S. Batie and R. G. Healy, "The Future of American Agriculture," Scientific American 248 (1983): 45-53.

[13] Data from Agricultural Statistics, 1989 (Washington: U.S. Department of Agriculture, 1989), p. 375.

[14] Historical Statistics, Colonial Times to 1970, p. 460; and Agricultural Statistics, 1990 (Washington: U.S. Depart ment of Agriculture, 1990), p. 359.

[15] The definition of "farm" for the 1989 data is somewhat different from the one employed for the 1880-1969 data. The new definition seems to include more area within farms. Thus, if the old definition had been used, the current area of farmlands would be further reduced.

[16] Historical Statistics, Colonial Times to 1970, p. 460; and Agricultural Statistics, 1990, p. 359.

[17] Statistical Abstract of the United States, 1991 (Washington: U.S. Department of Commerce, 1991), p. 204.

[18] D. Hatch, "Naturalists List the Beasts," New York Times, September 6, 1987, Section 23, p. 1; and E. Kolbert, "For Wildlife the Times Are Very Good," New York Times, November 23, 1986, Section E, p. 9.

[19] The 0.8 percent, though hardly satisfactory, is based on the increase between the 1961-65 average and the 1981-85 average in staple food crop production aggregated on the basis of calorie content weights, as provided in UN Depart ment of International Economic and Social Affairs, Overall Socio-Economic Perspective of the World Economy to the Year 2000 (New York: United Nations, 1991).

[20] The 2 percent per capita per year increase is just a shade below the historic 2.1 percent per capita per year increase in the gross world product between 1960 and 1990, as indicated in UN Department of International Economic and Social Affairs. See also, I. M. Goklany, "Adaptation and Climate Change," Paper presented at the Annual Meeting of the American Association for the Advancement of Science, Chicago, Illinois, February 6-11, 1992.

[21] P. Huber, "Exorcists vs. Gatekeepers in Risk Regula tion," Regulation 7 (November/December 1983): 23-32; and R. W. Crandall, "An Acid Test for Congress," Regulation 8 (Sep tember/December 1984): 21.