Agriculture, Trade, and Environment: Achieving Complementary Policies

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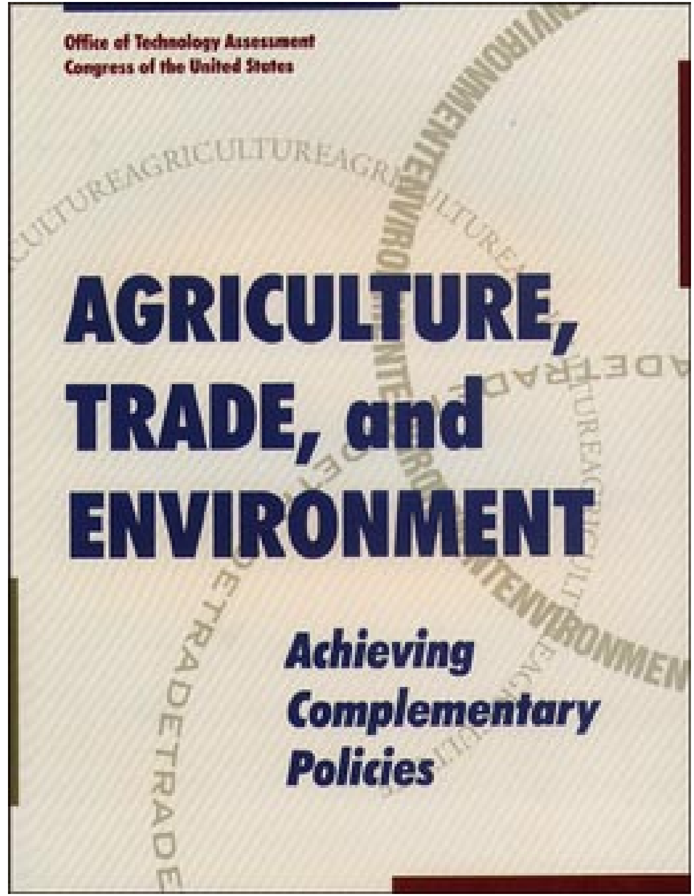

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Foreword

Times have changed. No where is that more evident than in U.S. agriculture. Increasing global integration, expanding world agricultural markets, and broadening environmental priorities both at home and abroad are defining new policy challenges for the United States. Passage of the North American Free Trade Agreement and the Uruguay Round Agreements of GATT have spurred debate about the effects that liberalizing trade might have on the environment, and these debates continue. As the 104th Congress prepares to deliberate reauthorization of the Food, Agriculture, Conservation, and Trade Act (FACTA), more commonly referred to as the 1995 Farm Bill, the relationships among agriculture, trade, and the environment are prominent subjects.

Anticipating further debates on free trade, on FACTA, the Clean Water Act, and other policy issues related to agriculture, trade, and the environment, Congress requested this assessment to provide guidance on policies and technologies needed for U.S. agriculture to be competitive in world markets and to ensure that environmental goals are met. Committees requesting the assessment were the Senate Committee on Agriculture, Nutrition, and Forestry; the House Committee on Agriculture; and the House Committee on Foreign Affairs.

This report provides information that can help align agricultural legislation with emerging needs and trends. Current policies do not ameliorate conflicts between agricultural production and environmental quality, between trade and the environment, and between agriculture and competitive trade. Opportunities for greater complementarity among these areas are possibly being missed.

Technology is integral to achieving complementarity. So often, agricultural technology has been developed for the sole purpose of increasing production with little attention to the market, environmental, or budgetary trade-offs. Unintended consequences have often been the result. Today, with the vast array of powerful scientific tools available, such as biotechnology and advanced computer technologies, it may be possible to develop technologies that incorporate multiple objectives, such as increasing production while enhancing environmental quality. Innovations in science and technology paired with future-oriented policies to guide agriculture, trade, and the environment could position the United States as a leader in world markets and in domestic environmental protection.

OTA greatly appreciates the contributions of the Advisory Panel, authors of commissioned papers, workshop participants, and the many additional people who reviewed material for the report or gave valuable guidance. Their timely and in-depth assistance allowed us to do the extensive study our requesters envisioned. As with all OTA studies, the content of this report is the sole responsibility of OTA.

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Note: OTA appreciates and is grateful for the valuable assistance and thoughtful critiques provided by the advisory panel members. The panel does not, however, necessarily approve, disapprove, or endorse this report. OTA assumes full responsibility for the report and the accuracy of its contents.

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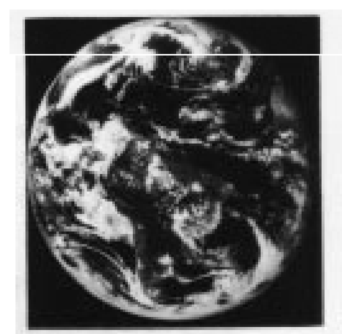


Summary and Overview 1

In the past few decades, the U.S. agricultural sector has become integrally and irrevocably linked to international markets and environmental interests. Once the dominant supplier, U.S. agricultural producers now must compete with numerous other international traders to fill the demands of global agricultural markets. At the same time, the effects of agricultural activity on the U.S. environment, and of environmental programs on agricultural production and trade, have become subjects of national importance. Within this new, multifaceted framework, international markets increasingly dictate domestic production and marketing decisions, and new priorities for environmental programs emerge. Also emerging, however, are questions about the efficacy and appropriateness of current government farm and conservation programs, many of which were instituted to cope with the exigencies of another time. In 1995, and into the next century, the key challenge for U.S. agricultural, trade, and environmental interests is to ensure that the nation's policies and programs are oriented toward the future, not shackled to the past.

This report assesses the current status of, and the diverse connections among agriculture, trade, and the environment. It delivers four major messages based on the overarching goal of promoting complementarity among them:

1. Global forces increasingly dictate the economic framework within which the U.S. agricultural sector operates, as well as the legislative framework for U.S. agricultural policy. As a result, current agricultural programs are more of a problem than a solution. Dismantling them would help the U.S. agricultural sector to respond better to the demands of global markets, and improve U.S. competitiveness abroad.

2. Current conservation programs focus too narrowly on old problems rather than on newer issues such as water quality, wildlife habitat, soil quality, and the environmental systems that join them together. Scientific knowledge of these newer issues is lacking.
3. Expanding agricultural trade does not pose significant short-run environmental risks, and environmental regulation overall does not impair the United States' ability to compete effectively in overseas markets. However, some isolated environmental damage related to trade and some cases of trade impairment will occur.
4. Federally funded research programs remain tied to an old agenda of producing more agricultural output, while research on international trade and environmental issues is dramatically underfunded. Opportunities for developing technologies that help the United States to meet its agricultural production, trade, and environmental objectives are being missed.

The United States is not alone in facing these problems. Other countries too are striving to liberalize trade while enhancing environmental protection and bringing their agricultural production sectors in line with market realities. Achieving some of these global goals may require multilateral action. Nonetheless, there is much that the United States can do on a unilateral basis to reorient its policies and programs to complement global forces while working toward national goals related to agricultural production, trade, and the environment. This report offers a range of forward-looking policy options (chapter 7) designed to benefit the three areas both individually and collectively.

GLOBAL INTEGRATION NOW IMPACTS THE UNITED STATES

In recent decades, global events and trends have had an ever-greater impact on the United States. On the economic front, the United States has switched from fixed exchange rates, which were controlled by the government, to flexible exchange rates, which are controlled by dynamic and volatile forces around the world. The country has also moved from a relatively closed economy to a more open economy, in which trade is a major force behind the restructuring of the nation's industries, including agriculture. As part of its more open policy, the United States has entered into a number of agreements that liberalize international trade. The most notable are the North American Free Trade Agreement (NAFTA) and the Uruguay Round Agreements (URA) of the General Agreement on Tariffs and Trade (GATT) (now the World Trade Organization, or WTO). On the environmental front, the United States has joined other countries in structuring more multilateral accords, such as the North American Agreement on Environmental Cooperation and the Montreal Protocol on Substances that Deplete the Ozone Layer, to protect transboundary resources and the global environment.

Poised to take advantage of more liberalized trade are multinational companies (MNCs) that control a substantial portion of the world (and the U.S.) economy. Their origins, sources for materials, communications, production facilities, and outlooks are increasingly global. Intrafirm trade—that is, goods and services exchanged among parent companies and their foreign subsidiaries—may account for 40 percent of U.S. imports and 35 percent of exports.

Facilitating the long reach of MNCs is global communications technology. Fifty plus years ago, when technologies such as radio and television first appeared, only a few wealthy countries felt its impact. Today, these and other global communications technologies allow hundreds of millions of people around the world to hear and see how others do things differently. With advanced computer systems, firms as well as individuals have instant access to global information, and trading goes on 24 hours a day. At the same time, the increasing exchange of scientific data and discoveries through communications technology has fostered an improved understanding of transboundary and global environmental systems. The result of these changes is that countries are much more interdependent. It is more difficult for a country to impede the flow of information or to prevent or even slow the transfer of technology. All of these massive forces of change mean actions taken by one country have major implications for others.

Although global integration has made the United States more dependent on other nations, it has also brought new and rewarding opportunities for the public and private sectors. U.S. industries can not only avail themselves of frontier science and state-of-the-art technology more readily and at reduced cost; they can also diversify production and marketing risks with overseas operations. The U.S. government can share science and data with other national governments to construct more accurate appraisals of transboundary or regional environmental issues, and private industry can export or import technologies to solve them. To take full advantage of the benefits of global integration, however, it is crucial for the United States to move toward new, far-sighted policies based on emerging conditions in the nation and the world. Implementing policies that promote mutually beneficial developments in agriculture, trade, and the environment is a policy objective consistent with the new forces.

AGRICULTURAL PROGRAMS NO LONGER REFLECT MARKET REALITIES

Global integration has had a profound impact on the U.S. agricultural system. No longer do national borders define the markets available to U.S. farmers and processors. Rather, the U.S. agricultural sector is using new organizational arrangements and marketing strategies to enter and compete in global markets. Farm inputs, new farm technologies, farm output, and new food products are all exchanged in this global agricultural system, of which the U.S. agricultural system is an important and interdependent part.

MNCs are responsible for most international business in food and agricultural products, handling farm inputs, food processing, food distribution, and fast-food restaurants. They draw on the entire world to supply their operations. If a drought or flood decreases grain supplies in the United States, for example, MNCs can obtain grain from Argentina, Brazil, Australia, or another country. MNCs in food processing are creating global sourcing networks for ingredients, food-processing equipment, and packaging systems. These developments and others have made for a global agricultural system that is extremely dynamic. Response time to marketing opportunities is shorter, resources are more mobile, and the level of competition is more intense in nearly all markets.

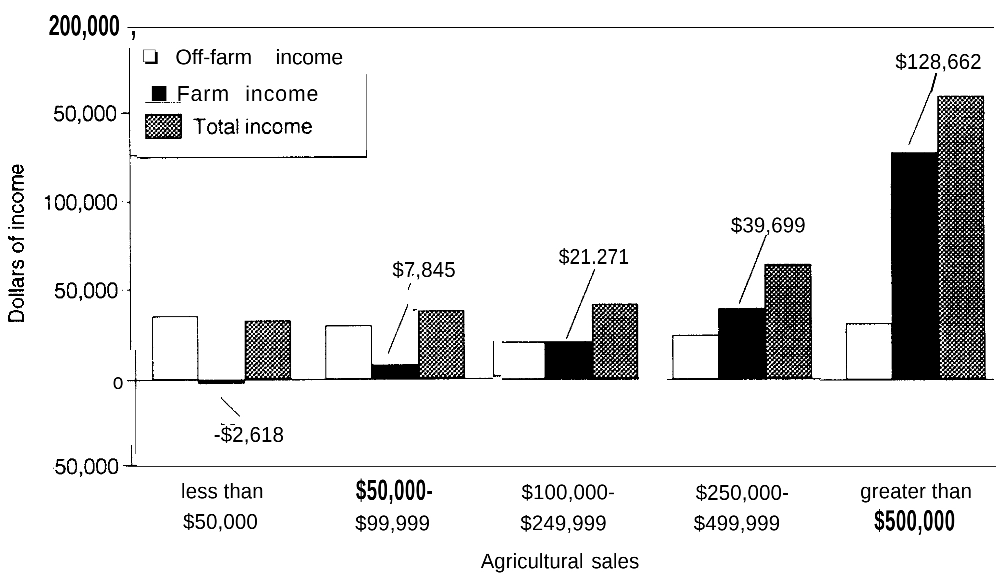
Unfortunately, current U.S. farm commodity programs do not provide the U.S. agricultural sector with the flexibility it needs to compete effectively in such a dynamic global agricultural system. These programs may have enhanced farm prices and farm incomes in earlier years, but now, they impose limits on land use and depress agricultural growth and competitiveness. The United States must seriously consider dispensing with these programs if it wishes to remain competitive in global agricultural markets.

Increased Market Orientation

As the previous sections explain, agricultural output, marketing decisions, and farmers' incomes are increasingly tied to global markets—which means that the traditional domestic demand and government program incentives that farmers looked to for guidance on what to plant, how to market, and what to export are steadily being replaced by market signals. Farm structure has changed as well. Six million farms produced the nation's food and fiber during World War II, but now, fewer than one million farms account for more than 95 percent of all U.S. farm output. Another million or so part-time farming operations add to agricultural supplies, although the operators of these farms earn more from jobs they hold off the farm than from farming itself.

Together, higher incomes on commercial farms and more off-farm income on part-time farms have brought farm households income parity with all other U.S. households. Within the farm sector, however, there is an enormous diversity of income: the largest farms receive incomes several times the national household average (figure 1-1).

FIGURE 1-1: Diversity of Farm Income



SOURCE: U.S. Department of Agriculture, Economic Research Service, *National Financial Summary,* ECIFS-13-1, 1993

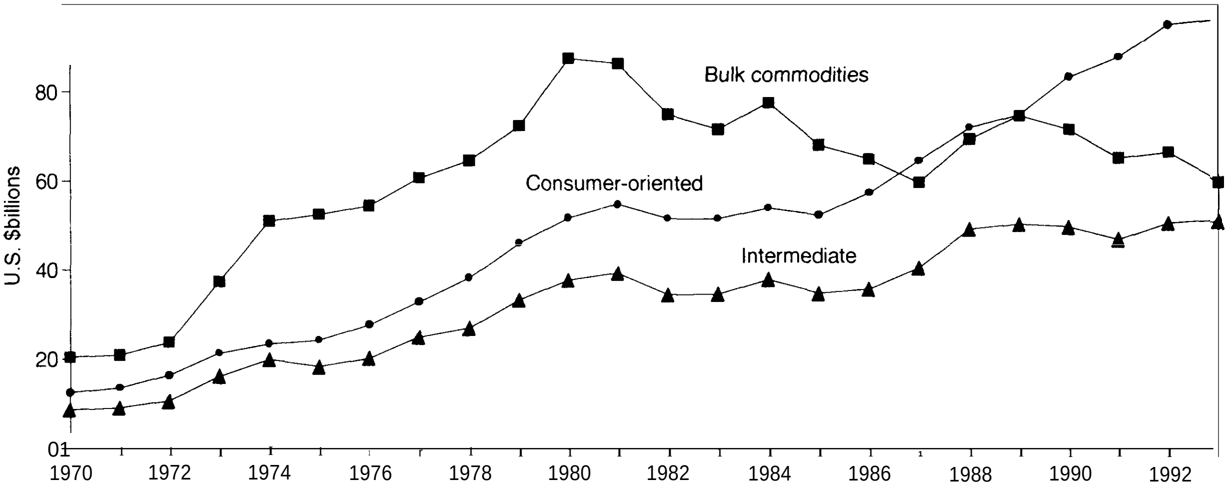
Nonetheless, the improved economic status of farm households overall has helped stabilize the farming sector, slowing the reduction in farm numbers and improving the asset position of farming operations.

A variety of technological, economic, and social forces combined in past decades to reshape the structure of farms and raise farm output. Farm size expanded as farm machinery grew in size and capacity. Farm output increased as each year's new crop varieties replaced the old. As domestic surpluses became the norm, commodity prices were depressed, forcing high-cost operators out of farming enterprises. Budget costs for disposing of stocks replaced concern over adequate food supplies. And, as environmental issues gained prominence, the American public placed greater emphasis on food quality, human nutrition, a safer food supply, protection of the environment, and the development of a sustainable agricultural system.

With new demands from consumers, new marketing arrangements emerged to improve the coordination of farm output with consumer needs. Contract production and vertical integration are used increasingly by agricultural producers, lowering economic risk and improving quality control. These new arrangements account for ever-larger portions of total output. Although open markets with many buyers and sellers still account for most sales of food and feed grains, for specialty crops and livestock the trend has been toward markets with relatively few buyers and sellers—many of whom establish terms of trade through contracts or vertical integration. Some 49 percent of fresh vegetable production, for example, moved through open markets in 1970, compared with 35 percent in 1990. Turkey production went from 28 percent of production moving through open markets in 1970 to 7 percent in 1990. Citrus production is now entirely handled through contracts and vertical integration. Overall, vertical integration and contractual arrangements, many involving MNCs, account for an increasing proportion of agricultural marketing.

As marketing arrangements have changed, so has overseas demand for agricultural products. Most notably, as the composition of other countries' agricultural imports has broadened, the

FIGURE 1-2: World Trade in Value Added Products



SOURCE: U.S. Department of Agriculture, Foreign Agricultural Service, *Desk Reference Guide to U.S. Agricultural Trade,* Agricultural Handbook No. 683, revised April 1994

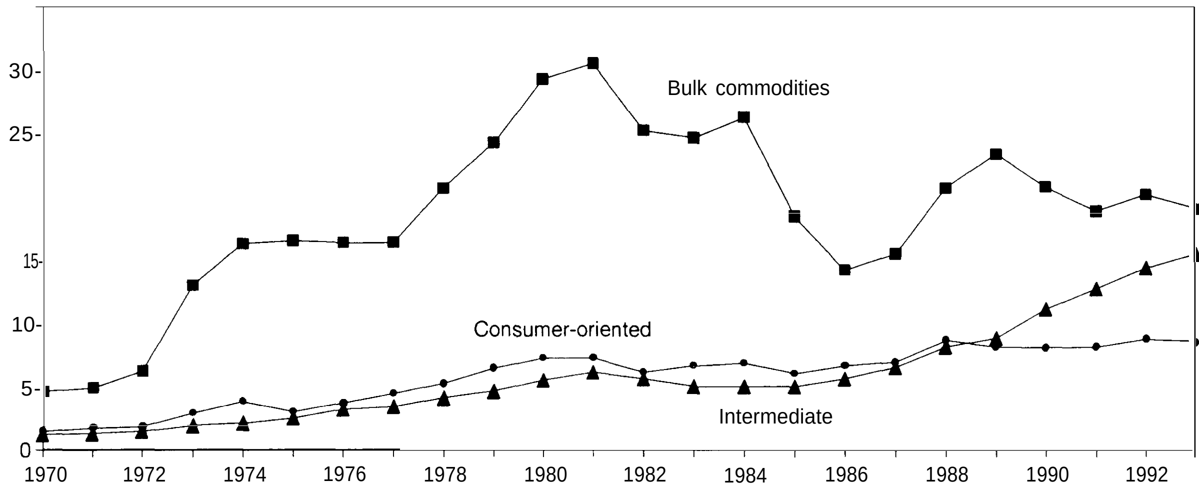
global market for value-added agricultural items has expanded.[1] Between 1972 and 1993, worldwide trade in value-added products grew at an annual rate of 8.5 percent, from $27 billion to $148 billion. By contrast, trade in bulk commodities increased from $24 billion to $60 billion, reflecting an annual growth rate of 4.5 percent. The share of world agricultural trade attributed to value-added food products was 71 percent in 1993, compared with 51 percent on 1970. The combined value of world trade in agricultural bulk commodities and value-added food products was $51 billion in 1972 and **$208** billion in 1993.

In keeping with the times, the United States has expanded its exports of value-added agricultural products, which now make up a majority of U.S. farm exports. However, value-added agricultural products dominate world food trade by a ratio of 2.5 to 1, while the ratio for U.S. exports is 1.25 to 1 (figures 1-2 and 1-3). U.S. exports of agricultural products have not grown as rapidly as world trade, leading to a loss in U.S. share of global agricultural markets. Part of the problem is the United States' continuing emphasis on bulk commodities, a legacy of farm programs that originated in the 1930s. These programs result in restraints on land use that limit the responsiveness of production to market forces. The programs also require multiple subsidies—first for producing bulk commodities, and then for disposing of them in export markets. Substantial budget savings and greater efficiency could be attained by gradually phasing out government-enhanced incentives for producing bulk commodities and allowing market signals to guide farm output toward expanding global markets.

Another useful change would be to redirect current market research efforts. Approximately 60 percent of all agricultural research expenditures is directed to increasing animal and crop production;

[1] Value-added food products include semi-processed products such as wheat flour, oilseed meal, and vegetable oil, as well as end products that require little or no additional processing for consumption such as fresh and processed fruits and vegetables, fresh and processed meats, and bakery products. Bulk commodities are products that have not been processed such as wheat, corn, cotton, and rice.

FIGURE 1-3: U.S. Trade in Value Added Products



SOURCE: U.S. Department of Agriculture, Foreign Agricultural Service, *Desk Reference Guide to U.S. Agricultural Trade,* Agricultural Handbook No 683, revised April 1994

less than 5 percent is spent on researching international and domestic markets. As global markets continue to change, more research on foreign market institutions and trends in agricultural trade, and their implications for U.S. agriculture, is essential.

New Technologies for New Markets

A range of new technologies complement the market trend toward value-added products. Information technology, for instance, enables firms to identify new markets and customize products to satisfy changing markets. The traditional constraints associated with variability in raw material supplies are slowly being removed, as new biotechnologies can alter a raw agricultural product to fit specific end uses. A highly publicized example of such a product was recently introduced by Calgene, a multinational biotechnology/information technology-based seed, food, and specialty chemical company that is developing proprietary plant varieties and plant products. Since the mid-1980s, Calgene has genetically engineered new kinds of tomatoes in an effort to significantly extend shelf life and improve taste. The company has successfully produced a fresh market tomato with at least seven to 10 days of extended shelf life. The consumer benefits are that the genetically engineered tomatoes may be harvested ripe for full flavor, shipped without refrigeration, and delivered fresh to domestic and global markets. The company received the first U.S. patent covering the use of genetic engineering in tomatoes and commercially launched the Flavor Savr tomato in 1994.

Calgene also provides a good example of the new marketing arrangements discussed above. The company will competitively select growers to produce and harvest the new tomatoes under specified conditions, will control the distribution of the tomato, and will merchandise it under its own label. Thus, Flavor Savr tomatoes will be available to consumers through a vertically integrated MNC that controls the product from seed to retail sale.

International Trade Agreements

Among the forces accelerating global integration of the agricultural sector are international trade agreements. Although most countries intervene in their agricultural sectors to achieve certain national objectives, the trend is overwhelmingly toward less government support. Trade agreements such as the URA complement this trend not only by requiring reductions in such support, but also by acting as a major impetus for policy to move toward greater flexibility to meet changing market conditions. The URA reduces tariffs on many of the agricultural goods traded among WTO members, which will increase competitive pressures and place a premium on the marketing skills of agricultural businesses worldwide. NAFTA completely phases out North America's regime of agricultural tariffs over the next decade and a half. Tariffs on about half of the agricultural products traded between the United States and Mexico were eliminated on January 1, 1994. Even though tariffs on "import-sensitive" products, such as corn and beans for Mexico, and orange juice, peanuts, and sugar for the United States, are being phased out more slowly, the trend toward open markets is clear.

The URA and NAFTA will expand markets for U.S. agricultural products. Conversely, U.S. markets will be opened to countries that may have a comparative advantage in the production and marketing of certain agricultural items. Because the United States already imports large amounts of agricultural products, and its tariffs have been among the world's lowest, it is unlikely that imports will jump dramatically. Nevertheless, competition will increase and markets will expand.

Even though they will help to redirect some U.S. agricultural efforts, international trade agreements alone cannot align U.S. production and exports with global markets. The URA provisions may focus U.S. attention on exporting more value-added food products, but current programs that support farm commodity prices and subsidize commodity exports (most of which show little promise of large export-value gains) will work at cross purposes with this trend. Not only are these programs clearly detrimental in terms of myriad trade opportunities and revenues lost; they also conflict with the spirit of international trade agreements, which the United States has, through the years, strongly supported. The United States is consequently reaching a point where it must choose between supporting global free trade and insulating its agricultural interests from the global marketplace. The challenge ahead is to allow the incentive system to encourage more production of items to meet expanding international markets.

ENVIRONMENTAL PROGRAMS DO NOT EMPHASIZE NEW PRIORITIES

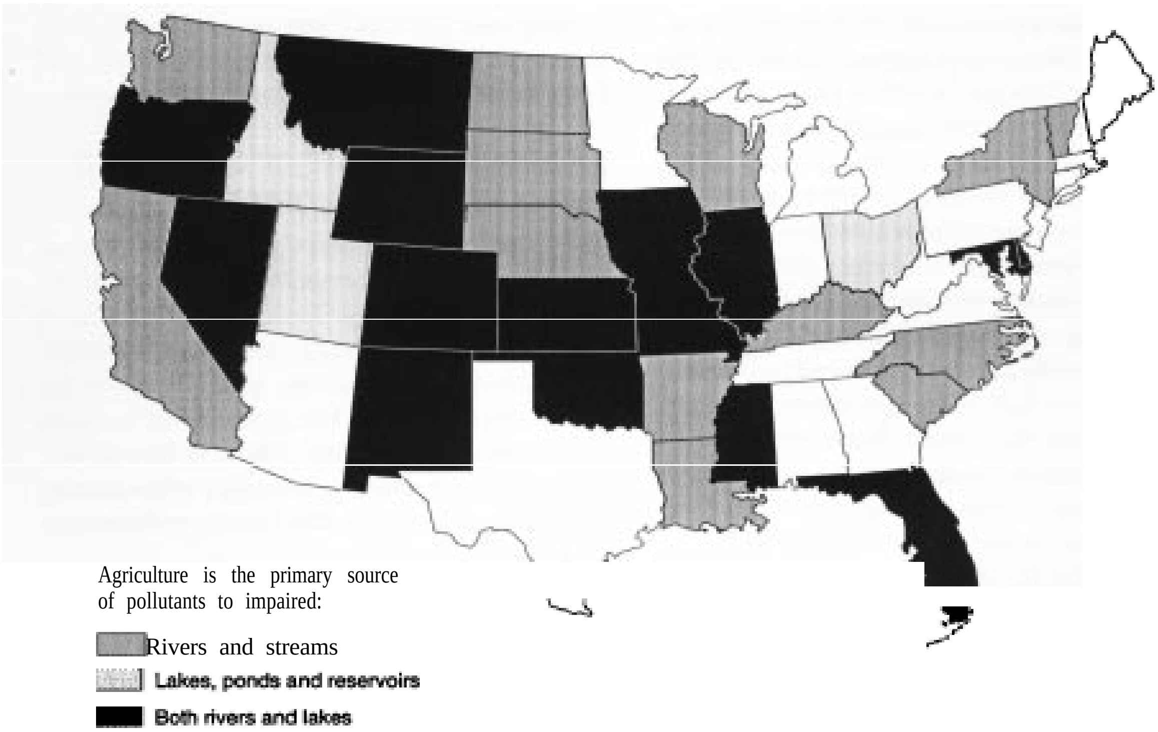
As it copes with the forces of global integration, the U.S. agricultural system is also facing new environmental dilemmas. Traditionally focused on soil and water conservation, the system must now deal more with water quality, wildlife habitat, and soil quality problems. The fundamental question confronting policymakers is how to take advantage of global market opportunities while making acceptable progress on this broader environmental agenda.

Environmental conditions associated with agricultural systems vary significantly throughout the United States. For the most part, this variation is simply a reflection of the diverse distribution of environmental resources across the national landscape. However, different types of agricultural production operations also create different types of environmental stress. Generally, the effects of agricultural operations on the U.S. environment are local or regional in nature. A first step toward defining possible federal program responses, then, is to appraise the pattern of environmental problems nationwide, so that priority areas can be identified and effectively targeted.

Agriculture's Effects on the Environment: Negative and Positive

Research and monitoring conducted since the 1970s provide broad evidence of both degradation and improvement in the quality of water, wildlife resources, and soil conditions affected by agriculture. Overall, water quality suffers most from its association with agriculture. Agriculture ranks as the primary contributor to today's surface water quality problems, principally through sediment deposition and agrichemical runoff from dryland and irrigated systems. Agriculture contributes

FIGURE 1-4: Agriculture's Role in Impairment of U.S. Surface Waters



States assessed only portions of rivers, lakes, and coastal estuaries in 1992. In 32 states, agricultural pollutants were the main source of pollution in surface waters that were unable to support their intended uses. Im paired estuaries in Oregon, California, Florida, Delaware, and Connecticut were predominantly effected by agricultural pollutants. Because four states did not report sources of pollution to rivers and lakes (Tennessee, New Jersey, Idaho, and Georgia), and six states did not report sources of pollution to lakes, ponds and reservoirs (Minnesota, Wisconsin, Tennessee, Pennsylvania, Vermont, and Alaska), this map may underestimate agriculture's role in those states.

NOTE: Data for Alaska and Hawaii is not available. States shaded whlte did not report agriculture as a source of pollution to impaired surface waters.

SOURCE: OTA, 1995. Compiled from data in U.S. Environmental Protection Agency, *National Water Quality Inventory 1992 Report to Congress,* EPA-841-R-94-G01, 1994.

pollution to over one half of the assessed streams, rivers, lakes, and reservoirs suffering impairments. As shown in figure 1-4, agriculture's relative importance to surface water impairments is spread throughout the country. Recent research indicates that more than 70 percent of U.S. cropland is located in watersheds of "poor water quality," where at least one agricultural contaminant exceeds recreational or ecological health guidelines. Nitrate in groundwater appears to be increasingly prevalent: 16 percent of the samples taken from under agricultural lands show nitrate levels that exceed drinking water standards. Although incomplete, groundwater monitoring of agricultural pesticides indicate that residues exceed drinking water standards in some states.

Overall, wildlife habitats (and as a result, wildlife populations) have been diminished or degraded by agricultural cultivation, drainage, and pollution for the past half-century. Indeed, agricultural production has been the nation's leading cause of habitat alteration, including wetlands alteration, and is the most prominent activity endangering species today. It is important to note, however, that selected wildlife species, such as pheasants and migratory waterfowl, have made significant recoveries since conservation land set-aside programs began in the mid-1980s, indicating that reversals are possible.

Dramatic improvements have been made in controlling soil erosion. Overall, soil erosion levels have fallen 50 percent since 1945 and one-third over the past decade. The benefits are not only lower productivity losses but also future improvements in water quality as reduced pollution from sediment, nutrients, and pesticides allows rivers, wetlands, estuaries, and reservoirs to recover. Not all regional erosion trends are positive, however: some areas have been subjected to greater stress from cropping and production practices. And 120 million acres are still eroding at levels considered excessive for maintaining productivity while also causing environmental damages. Aspects of soil quality apart from erosion, such as microbial activity, have not been monitored and cannot be evaluated at the present time.

Incomplete and Ineffective Program Coverage

Today, at least 40 federal programs give incentives to farmers and ranchers to adopt conservation and environmental technologies. There are three basic approaches: 1) voluntary programs, which provide education, technical assistance, and/or subsidies for practice cost-sharing and land rental; 2) compliance measures; and 3) regulation. An overall evaluation of each approach or for the total set to assess duplication, conflicts, and coverage has not been conducted. However, existing evaluations indicate that strategic improvements are possible to improve long-term environmental performance while saving public and private costs.

Voluntary educational and technical assistance programs, often coupled with subsidies, grew out of the Great Depression "Dust Bowl" soil erosion problems, and remain the government's dominant approach. There is a lack of scientific evidence to indicate that educational and technical assistance programs have produced significant environmental improvements, except when combined with subsidies. Whenever sufficient private economic incentives exist, farmers will eventually adopt environmentally preferable production technologies without public educational or technical assistance programs. The explosion of so-called conservation tillage technology over the past decade and the growing use of field nutrient testing to cut fertilizer use are two prominent examples. These successes with "complementary technology"—technology that simultaneously benefits agricultural operations and the environment—arose largely without public research or education program initiatives. The benefits might be even greater if public policy targets resources to such innovations and helps spread adoption farther and faster.

Subsidy programs, by themselves or in conjunction with education and technical assistance, have produced conservation and environmental gains. However, they generally have not been targeted to address areas suffering the largest damages and have not always encouraged cost-effective practices. For example, enrollments in the Conservation Reserve Program (CRP), under which the government "rents" environmentally vulnerable land from farmers, did not initially include some of the nation's most fragile lands. Further, the CRP rules did not permit farmers to produce profitable commercial crops on the enrolled land, even if they could simultaneously meet the program's environmental objectives—a feature that could have lowered the government's rental payments and enhanced international competitiveness. Enrollment procedures instituted after the Food, Agriculture, Conservation, and Trade Act of 1990 improved CRP targeting, but in general did not allow the enrolled land to be used commercially. Careful targeting and greater attention to costs will be essential to the success of future subsidy programs, which will likely have much more limited scope as a result of federal budget pressures.

Compliance schemes, a landmark development of the 1985 Food Security Act, link farmers' agricultural program payments to environmental improvement. The programs cover the use of highly erodible cropland, pasture or grassland conversion, and wetlands alteration. Perhaps because the compliance measures were untried, their implementation was slow and filled with uncertainty. Regardless of their efficacy to date, the schemes suffer from two basic shortcomings. First, the size of the compliance penalties, and so the incentives to meet given standards, are not necessarily aligned with environmental priorities. Second, compliance schemes depend on the continued renewal of adequate agricultural program benefits—an increasingly difficult and costly proposition in the face of budget constraints and global agricultural economic integration.

The use of voluntary subsidy approaches and the difficulty of monitoring pollution from agricultural lands—the nonpoint source problem—has meant that agriculture has been subject to less environmental regulation than other industries. However, a growing number of regulations have surfaced over the past two decades, and their perceived influence on farmers' management decisions is growing. Pesticide registration, involving a protracted and costly review process that is behind schedule, may have the broadest effects. The regulation of pesticides has not meant overall economic loss for the industry, but it has disadvantaged specific sectors and retarded innovation that could result in environmental improvement. For example, the registration of new or existing pesticides for "minor use" crops, such as many fruits and vegetables, has been a problem because the registration costs do not compare favorably with the pesticides' small market potential.

The problems with regulation extend beyond pesticides. Long delays and conflicting rulings from multiple agencies have plagued some farmers' attempts to obtain permits for altering wetlands. Even though the percentage of these troublesome cases is small, their very existence may have spread uncertainty to other farmers who will not be likewise affected. The prospect of future regulations to protect endangered species, control coastal zone water pollution, or address other environmental issues adds more uncertainty for farmers in planning their production operations. Further, the implementation of regulations is often uneven across states. For example, point-source water pollution from confined animal operations is regulated under federal water quality programs delegated to states, and the states have widely differing approaches. Allowing states to use different approaches to pollution control may cause problems, however, when pollutants migrate across state boundaries.

Taken as a whole, the current mix of regulations, voluntary programs, and compliance schemes neither cover the broader set of environmental priorities nor operate efficiently. As matters stand, there is no clear set of environmental objectives and priorities for the agricultural sector, and excessive costs for producers, consumers, and taxpayers, as well as environmental losses, result. Further, inadequate understanding of agroenvironmental systems, conditions, and health implications can lead to uncoordinated programs and ineffective signals for the agricultural sector regarding the goals of production, technology development, and environmental protection. Clarification of agriculture's environmental responsibilities, including public and private roles and improved science would reduce uncertainty and help target scarce public resources to environmental priorities.

EXPANDED TRADE CAN COMPLEMENT ENVIRONMENTAL PROTECTION

As global economic integration proceeds, and as domestic and international environmental agendas broaden, two subjects of increasing concern have been how trade might affect the environment, and how environmental regulations might affect trade. Whether the forces of expanding trade and environmental protection can work together, or whether they necessarily conflict, has been a matter of intense debate. Over the past 20 years, the scope of the debate has widened from domestic economic and environmental issues under U.S. jurisdiction to include international commerce and global environmental questions. The simple label "trade and environment" consequently covers a large, complicated, and ever-growing web of topics that are crucially important to legal, economic, and environmental interests alike. Four aspects of the relationship between trade and the environment merit special attention.

First is the effect of environmental regulation on trade. According to some schools of thought, costly environmental regulations can force domestic producers to lose export markets or move overseas. Studies of nonagricultural industries indicate that overseas migration resulting from environmental regulations has not been significant overall, and that trade has been little affected. Because the U.S. agricultural sector is subject, for the most part, to voluntary conservation and environmental programs implemented with subsidies, its compliance costs are low, and so its competitiveness in world markets is relatively unhindered. Moreover, competitors abroad must comply with agroenvironmental programs similar to those affecting the U.S. agricultural sector as discussed below. Ultimately, the effects of a larger environmental agenda on trade will depend on the types of environmental and other programs implemented to promote mutually beneficial outcomes.

Some specific sectors with special environmental problems may be exceptions and find that their competitiveness is hindered as a result of environmental regulation. The most noteworthy case thus far concerns methyl bromide, a chemical used in agricultural production and trade, and slated to be banned in the United States because it contributes to air pollution. Although the benefits to U.S. society as a whole of banning methyl bromide are estimated to far exceed the costs, some agricultural sectors will suffer disproportionately, losing about $1 billion per year in the short term. Cases such as methyl bromide should be the focus of research to investigate the policy opportunities, domestic and multilateral, to ease adjustment, create better substitute technologies, and help retain international markets.

Second is the role of product standards. National product standards, such as tolerance levels for pesticide residues, can serve as legitimate nontariff measures to screen certain imports. The URA established new health and safety, as well as "technical barriers to trade," codes that address this issue. Among other things, the codes specify that product standards should be based on science and restrict trade no more than necessary to achieve a nation's desired level of protection. The specific aim of these new negotiated agreements was to reduce the likelihood that U.S. agricultural exports would be subject to unwarranted import barriers. However, product standards are also crucial to addressing certain environmental ills related to agriculture. For example, keeping harmful nonindigenous species (HNIS) out of the United States (now a significant environmental concern) depends primarily on strictly enforcing measures covered by the codes, such as quarantines. Because of the lack of precedent under the URA, it is not clear whether product standards for environmental purposes will come under fire as unjustifiable barriers to trade. If they do, only future rulings by the WTO will determine their status. Other agricultural-trade-environmental issues extend from product standards to the growing gray area of process standards, currently illegal under WTO rules. Examples include the enforcement of domestic country rules excluding genetically engineered plants and animals and market standards for organic farm products. Multilateral attention to these issues could enhance U.S. production and environmental interests.

Third is the effect of trade liberalization and expansion on the environment. Estimated shifts in agricultural production that result from the new trade agreements will likely cause little overall damage to the U.S. environment. Indeed, environmental conditions may improve in some areas, if imports displace environmentally damaging domestic production. Certain other areas—such as border zones, where trading could flourish—may come under added environmental stress, and foreign species, such as invasive weeds on rangelands, could pose new commercial and environmental risks as they enter through new trade pathways. Controlling these short-run domestic environmental quality challenges and longer-term conflicts hinges principally on how U.S. agroenvironmental programs are run. As explained above, current programs are not wholly effective: they do not offer comprehensive and enduring environmental coverage, nor do they encourage complementary technology research and development. NAFTA and the URA do not require the United States to reduce current commodity program payments affecting production, or to "decouple" (that is, separate) the payments from levels and type of crop production. Had the URA significantly reformed domestic agricultural commodity programs, some net environmental improvement would likely have occurred. The net effect of such reform depends on weighing increased erosion pressure against less chemical use.

Expanding agricultural production through trade liberalization may pose special risks for countries that have inadequate environmental programs and would respond to higher world prices by producing more for export. Pressures on transboundary and global environmental resources of interest to the United States, such as border water resources and wildlife habitats, may result in significant costs. With the exception of the environmental side-agreement approved with NAFTA, neither the URA nor the present patchwork of multilateral environmental agreements addresses this kind of situation. Trade agreements will not cover all environmental problems because of their necessary orientation to commerce. Some type of multilateral environmental agreement or organization to coordinate and stimulate solutions to transboundary and global environmental problems is also required.

Fourth is how trade measures are used to meet international environmental objectives. NAFTA and the URA were the first trade agreements to incorporate significant environmental provisions, but the ultimate efficacy of those provisions depends on future political dynamics. The use of trade measures in a limited number of international environmental agreements, such as the Montreal Protocol to Control Substances that Deplete the Ozone Layer, has been shown effective. Current WTO rules do not specifically address the use of international environmental trade measures, and therefore clear guidelines are not at hand. Further, critical questions about the conditions justifying unilateral or multilateral actions and extraterritorial objectives remain unanswered. Such "offensive" environmental trade measures have not been widely applied to agriculture, although they may be in the future. Clear rules promulgated by the WTO would assist environmental and trade efficiency. Again, a multilateral organization responsible for global environmental management could work with the WTO to ensure that both global trade and environment needs receive appropriate consideration. Such an organization could help promote alternative measures, such as technical assistance and technology research and development, to avoid unnecessary trade disruptions.

Efforts to expand agricultural trade and upgrade environmental quality can complement each other, if "appropriate" environmental management programs that target significant environmental problems and focus on low-cost solutions are properly run. To achieve this outcome research needs to be targeted on these problems and solutions. Unfortunately, current programs at domestic and international levels do not ensure that this will happen. Reconstitution and retargeting of domestic environmental programs and technology research and development, introduction of new multilateral institutions, and greater levels of multilateral cooperation are essential.

AGRICULTURAL RESEARCH NEEDS A NEW DIRECTION

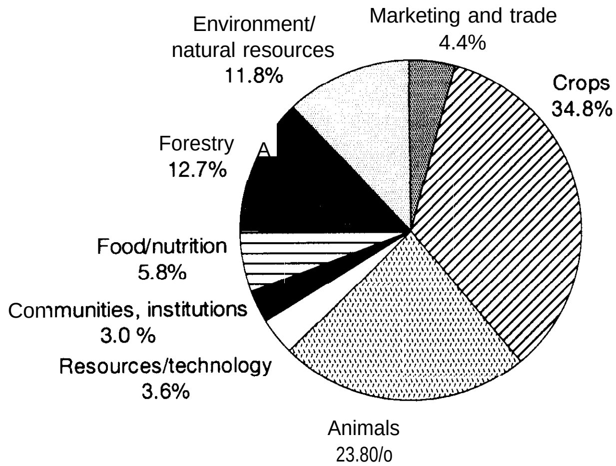
For many years, the nation has benefited from a long stream of agricultural research breakthroughs that have increased agricultural output and lowered the real cost of food. However, relatively little research has been directed toward agriculture's relation to trade or to the environment. Little if any information on changing trade flows, new and emerging agricultural markets, and strategies to meet the needs of those markets is available. On the environmental front, comprehensive information is not available on national trends in water quality, soil quality, and agriculture's effect on wildlife resources. Moreover, the potential for science to aid in devising complementary technologies remains largely unexplored.

A primary explanation for these differences in research achievements can be found in the budgetary resources allocated to these topics. In 1993, the United States devoted $2.9 billion to agricultural research through federal and state research institutions. The allocation of these funds heavily favored research on crop and livestock production (figure 1-5), which received almost 60 percent of all resources. Funding for research on the environment was only 12 percent, and for research on trade, a mere 4 percent. As a result, many potential chances to improve environmental conditions and trade revenues are being missed, and many key developments in world markets are identified belatedly, if at all. The dramatic shift of world trade away from bulk commodities and toward value--added agricultural products, for instance, went unnoticed for nearly a decade.

To take advantage of the trade opportunities available to it, the U.S. agricultural community needs information on markets in a wide range of countries. Food consumption trends in other countries, as an example, are important to track. Many of the countries that will be responsible for shaping the composition of future global trade in agricultural products are in different stages of development, with different income levels and different responses to changes in incomes, food prices, and availability of new food products. For the United States to become proficient at marketing agricultural products to these countries, it must become more knowledgeable about their conditions, about food tastes and taboos, and about cultural habits that shape food consumption. This new direction would present a major challenge to an agricultural research community that has focused most of its attention on enhancing yields of commodities that are declining in relative importance in international markets.

The relatively low priority of agroenvironmental research is reflected in the fact that federal agencies do not have major initiatives to understand the relationships between agricultural and environmental systems. Nor do they collect or maintain databases designed to evaluate comprehensively national water quality, trends in soil quality (except for erosion), or agriculture's effects on wildlife resources. Individual agencies monitor conditions separately, resulting in incompatible databases for building a national picture.

FIGURE 1-5: Agricultural Research $ Breakdown



Total funding $2,970,911,000

SOURCE: USDA/CSRS, Inventory of Agricultural Research, 1993

Finally, even with adequate national monitoring data, the implications of those conditions for environmental health remain poorly understood. For example, many agrichemicals have not been evaluated fully for their potential effects on the health of humans or environmental systems. Because market incentives to enhance environmental quality are incomplete, it is unrealistic to expect sufficient research and development to emanate from the private sector. Public research to provide adequate science and data on agroenvironmental topics, and for developing complementary production and environmental technologies, is clearly necessary.

The low level of funding for agroenvironmental research and lack of major program support for complementary technology, will slow the reorientation of public research priorities from traditional production emphases to enhancing the integration of production and environmental goals. Given the current research system, promising new developments in biotechnology, biological pest controls, and information technologies to increase the efficiency of inputs will not reach their full potential. Only anew generation of integrated research and technology developments can set the stage for an economically and environmentally sustainable agricultural system.

THE VIEW FROM ABROAD

Issues relating to agriculture, trade, and the environment are clearly not unique to the United States. The question is, how similar or dissimilar are the specific problems faced by other countries, and what kinds of policies are they implementing to address the problems? Are other countries experiencing agroenvironmental problems similar to those of the United States? How do their responses compare with ours? If the United States regulates agriculture to preserve its environment, will it still be competitive in world agricultural markets? Do other countries offer more support to their agricultural sectors than the United States does, or less? Do other countries restrict agricultural trade more, or less?

All of the countries considered in this report (Argentina, Australia, Brazil, Canada, France, Germany, Japan, Mexico, the Netherlands, New Zealand, Taiwan, and the United Kingdom) intervene in their agricultural sectors to achieve certain national objectives, such as maintaining a secure, safe, and adequate food supply; increasing agricultural productivity; and enhancing the living standards of farm families. In recent years, however, budget constraints, international pressure, and socioeconomic changes have led almost all of these countries to cut back on government support for their agricultural sectors. New Zealand went so far as to eliminate government support altogether in 1984, other than for pest and disease control and some research. Mexico and the European Union (EU) have advanced efforts to decouple agricultural support from product prices. As part of its economic reforms, Argentina has drastically reduced the implicit tax it levies on its agricultural sector.

This is not to suggest that barriers to agricultural trade are becoming obsolete. All countries continue to use some combination of border measures—tariffs, quotas, export promotions, health and safety regulations, licensing schemes, and other devices—to protect domestic agricultural producers and enhance their opportunities to increase agricultural exports. Taken together, these measures can restrict overall world trade. However, through increased participation in regional trade blocs such as NAFTA, and in the WTO, many countries are choosing to liberalize, rather than hinder, agricultural trade.

This move toward freer trade coincides with growing environmental concerns and a range of government efforts to address those concerns. By the mid-to-late 1980s, most governments had instituted at least some environmental legislation and regulations, and had taken moderate measures to help mitigate problems. Generally, in the industrialized countries, the percentage of GDP that is used for pollution abatement and control by the public and private sectors averages less than 2 percent.

Although the nature and extent of the problems may vary, most countries are contending with similar agroenvironmental concerns. Until recently, though, the agricultural sectors of most countries were generally not subject to environmental policies and regulations. Initial policies addressing agroenvironmental issues focused mostly on soil erosion, because it directly affects agricultural productivity. As the agroenvironmental agenda has broadened, however, many countries have begun to implement provisions for enhancing water quality as well as protecting habitats, wetlands, and countryside amenities in their agricultural policies. Canada, Japan, and the United States have each reduced their wetlands by more than 70 percent in some regions, but have now introduced policies geared to protecting remaining wetlands that are deemed significant, or to preventing a net loss of all wetlands.

Most countries are coping with the environmental effects of agricultural production by discouraging harmful practices or encouraging beneficial ones through a variety of programs. It must be kept in mind, however, that federal programs designed to assist agriculture still emphasize production rather than general environmental goals. To a large extent, existing agricultural policies either effectively raise farmers' prices for output, or decrease prices for inputs—both of which encourage farmers to adopt intensive farming practices that may be harmful to the environment. Agroenvironmental policies are then introduced to counteract these effects, but the artificially high prices for agricultural goods make it difficult for such policies to work. It is more profitable for farmers to use land for agricultural purposes than to let it be used, for example, as wildlife habitat, and agricultural programs enhance this disparity.

This dilemma is being addressed now by governments the world over. Confronted with shrinking budgets, they are finding it more and more difficult to rationalize maintaining such conflicting policies—and they are increasingly unwilling to pay not only the financial, but also the environmental, costs of supporting their agricultural sectors as they did in the past. Partly as a result, agroenvironmental policies are moving away from strictly voluntary efforts to cross-compliance schemes and regulatory measures. These policies may increase production costs, but if all countries are implementing similar policies and all face increased costs, the ultimate effects on competitiveness may be minimal.

A NEW CONTEXT FOR POLICY

Global integration, expanding and changing world agricultural markets, and heightened environmental concerns are defining new policy challenges and opportunities for the United States. These trends manifest themselves in an agricultural system that must respond more to global markets; an emerging environmental agenda that extends beyond traditional conservation concerns; and an expanding research agenda that increasingly emphasizes environmental protection, food safety, marketing and trade, and profitable, yet environmentally sustainable agricultural systems.

While the context has changed, federal policies and programs affecting the agricultural sector have not changed. They promote production of bulk commodities and hinder possible opportunities for U.S. farmers in fast growing value-added export markets. They divert major resources to soil conservation while newer issues of significance—water quality, wildlife habitat, and soil quality—remain relatively neglected. Almost two-thirds of agricultural research funding is devoted to increasing farm output, even though more output will mean more federal subsidies to export surplus crops, and still more federal funds to "idle" land to control surpluses.

As the United States moves toward the year 2000, and as continuing budget pressures constrain traditional subsidy solutions, government must explore innovative approaches to these dilemmas. Furthermore, tensions between agricultural policies and trends in both trade and environmental spheres create costly inefficiencies. Seeking complementary and mutually reinforcing policies for agriculture, trade, and the environment could not only lessen budget pressures but also help ensure that the nation's policies are oriented to the future.

Seeking complementarity would involve:

- synchronizing domestic trends with global forces,
- targeting program resources on priority areas,
- encouraging development of technologies that serve multiple objectives, and
- using markets or market-like mechanisms wherever possible.

Policy options discussed in chapter 7 for agriculture, trade, and the environment illustrate how policies and institutions can be complementary rather than in conflict. Central to the process will be allowing market forces to have more influence in food production while at the same time compensating for the market's inability to signal the value of environmental effects that result from agricultural production. Modern market forces are tuned to world-wide trends. Their signals help guide production patterns toward future markets, rather than tie them to past patterns of use. Those same signals can help research institutions determine research priorities that are consistent with national and international trends. Current commodity and conservation programs tie U.S. agriculture to the past. To provide complementarity among agricultural production, trade, and the environment many current programs need to be dramatically restructured, if not eliminated; fundamental policy changes need to be considered.

The pace of change must be carefully planned, however, so that the agricultural system and related environmental stresses are not thrown out of balance by abrupt suspension of federal programs. In chapter 7, a number of policy options are spelled out that would move federal programs toward a better balance with international markets, budget realities, trade deficits, and environmental concerns. The time sequence is five years which is in keeping with the time framework of recent agricultural legislation.

As the United States heads into the next century, such complementarity could have a key influence on the standing of U.S. agriculture in a global economy. Indeed, seeking complementarity among these policies will allow the United States to capture the opportunities of global market expansion while protecting and advancing domestic goals related to environmental quality as well as to the competitiveness of the agricultural sector. Moreover, seeking complementary and mutually reinforcing policies will likely require fewer government resources in an era of increasing budget stringency. Equally important, pursuing complementarity can help ensure that the nation's policies are oriented to the future, not anchored to the past.

The U.S. Agricultural System and Global Markets 2

Far-reaching changes in technology, domestic and global markets, and organizational structure have had a profound impact on the U.S. agricultural system. Within the new framework that has evolved, agricultural output, marketing decisions, and farmers' incomes are tied ever more tightly to global markets and market prices. The traditional beacons of domestic demand and government farm programs, which farmers looked to for guidance on what to plant, how to market, and what to export, are steadily being replaced by market signals—signals that emanate from many different countries and filter through markets located in urban areas like New York, Chicago, Memphis, and Kansas City.

The structure of farms has changed as well. Six million farms produced the nation's food during World War II, but now, a commercial agricultural sector of less than one million farms accounts for more than 95 percent of all farm output. Another million or so part-time farming operations add to agricultural supplies, although the operators of these farms earn more from work they do off the farm than from farming itself. Together, higher farm incomes on commercial farms and more off-farm income on part-time farms have raised farm household incomes to the national average of all U.S. households. The improved economic status of farm households has helped to stabilize the farming sector, slowing the loss of individual farms and helping more farms to stay solvent.

As technological, economic, and social forces have combined to increase the average size of farms, farm output has increased. As output has grown—as domestic surpluses have become the norm, and budget costs for disposing of stocks a major concern—

public debate over adequate food supplies has been supplanted by concerns about food quality, human nutrition, food safety, environmental protection, and the development of a sustainable agricultural system. In this new paradigm, farm tillage methods have changed and the environmentally unfriendly moldboard plow has largely disappeared; fertilizer and pesticides have been monitored more closely for their impacts on water quality as well as crop output; and biotechnology has been hailed as an evolving technology that can potentially improve productivity as well as enhance food quality, food safety, and environmental quality.

Faced with new demands from consumers, farmers have devised new marketing arrangements to better match farm output with consumer needs. Contract production and vertical integration (in the first instance, producing goods according to strict contractual stipulations; in the second, putting functions such as production, marketing, and retailing all under one roof) have become crucial to agricultural production, lowering economic risk and improving quality control. Simultaneously, developments in other countries have broadened the composition of their agricultural imports, expanding markets for U.S. value-added food items (a category that includes processed grains, fruits, vegetables, and meat). As U.S. exports of bulk commodities (mostly raw grains) slumped in the early 1980s, exports of value-added foodstuffs continued to grow, offsetting some of the loss in export earnings. Even though exports of U.S. value-added foods expanded, however, total global trade in these items expanded faster—which means that the United States, relatively speaking, has been losing ground in global food markets.

Part of the problem is the United States' emphasis on bulk commodities, a legacy of current farm programs that originated in the 1930s. These programs result in multiple subsidies, first for producing bulk commodities, and then for disposing of them in export markets. Substantial budget savings and greater efficiency could come from gradually phasing out incentives for producing bulk commodities, and allowing farmers to respond more appropriately to expanding global markets. Another useful change would be to redirect current market research efforts. Approximately 60 percent of all food and agricultural research expenditures is directed to animal and crop production; less than 5 percent is spent on researching international and domestic markets. As global markets continue to change, more research on changing trends in food trade, and their implications for U.S. agriculture, is essential.

With farm incomes higher, and with global markets now boosting demand for U.S. agricultural products (especially value-added food exports), the nation has an opportunity and, some would argue, the government an obligation to formulate new policies for U.S. agriculture. As a foundation for developing future legislative options, this chapter examines in detail the state of the U.S. agricultural system, its evolution over the past few decades, and its operation in the current economic and technological climate.

THE AGRICULTURAL PRODUCTION SYSTEM

U.S. agriculture has undergone tremendous changes in the course of this century. Gone are the days of the Great Depression, with its low prices and incomes. Gone are the days of World War II, when more farm output was deemed a national priority. Gone are the post-war decades of agricultural adjustment, when surpluses burdened markets and farm numbers sometimes fell more in a single year than they now fall in a decade. Today, agricultural productivity is impressive, resources are concentrated on larger farms although part-time farming is widely practiced, and farm household incomes have improved considerably. Despite the changes, agriculture remains an industry of enormous diversity, in terms of geography, production systems and practices, and in terms of income levels and asset values.

Commercial Farms and Agricultural Output

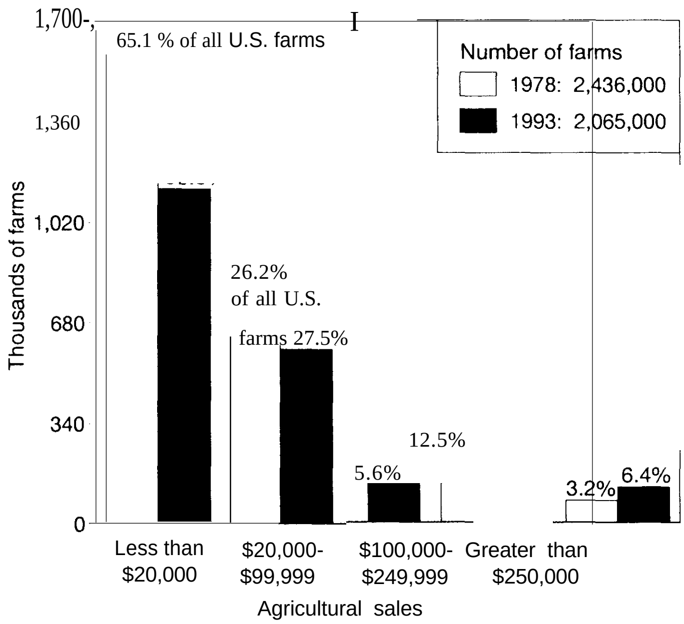
The structure of the U.S. agricultural sector has been streamlined substantially over the past few years, as a consequence of four key factors. First, technology in the form of mechanization allowed individual farmers to handle more acres of land, while new technology in the form of higher yielding seed varieties and pesticides increased output and lowered real commodity prices. Second, lower real prices cut into the incomes of farmers who were unable to produce more, leading some of them to seek jobs off the farm and others to retire. In both instances, other farmers generally took over their land. Third, farmers learned to manage their land better; and fourth, job opportunities off the farm grew. Slowly, the six million farms that existed during World War II became two million farms by 1994.[1]

The decline in farm numbers reflects the loss of more small, part-time operations (those selling less than $20,000 worth of output) than larger commercial farming operations.[2] In 1978, some 1.6 million farms sold less than $20,000 worth of output. Most were part-time operations. By 1993, the number of such farms had fallen to 1.1 million, a loss of 500,000 farms over 15 years (figure 2-1). In this same period, the number of farms selling more than $20,000 worth of output actually increased, rising from 908,000 farms to 960,000 farms (22).

As the total number of farms declined, the shares of output accounted for by commercial and part-time farms changed. Part-time farms (under $20,000 worth of sales) accounted for 7.5 percent of all farm output in 1978 and 6.2 percent in 1993 (figure 2-2). Intermediate-size farms-farms selling between $20,000 and $100,000 worth of output—also lost in terms of share of production: they accounted for 30 percent of farm output in 1978 and 17 percent in 1993. Larger farms-those selling more than $100,000 but less than $250,000 worth of output annually—increased their share of total farm output from 18 percent in 1978 to 21 percent in 1993. Farms selling more than $250,000 worth of output each year also increased their share of total farm output. Although they represent only 6 percent of all farms, these enterprises now account for 57 percent of all farm output, up from 45 percent in 1978.

The fact that only two million farms, or more accurately one million commercial farms, can sat-

FIGURE 2-1: Number of Farms by Size of Sales

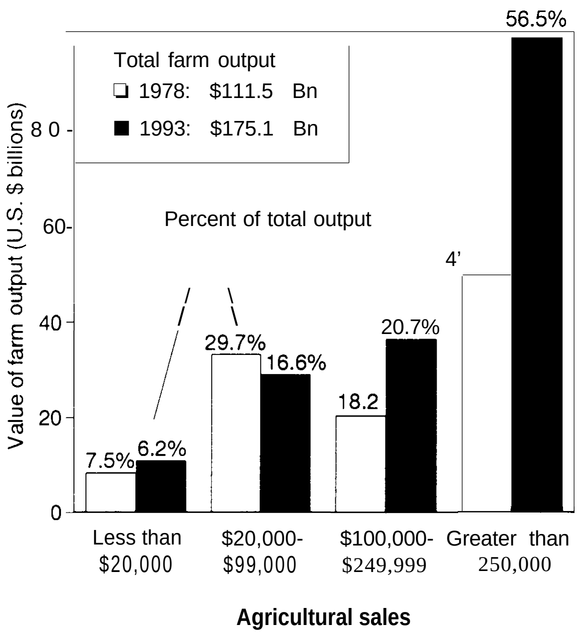


SOURCE: U.S. Department of Agriculture, Economic Research Service (EC IFS 13-1), Economic Indicators of the Farm Sector, *National Financial Summary* 1993

[1] The number of farm varies according to whose estimate is used. The 1992 Census of Agriculture counted 1,925,000 farms, but excluded farms currently in the Conservation Reserve program (CRP) and farms producing Christmas trees. Horse farms were included. The U.S Department of Agriculture's (USDA) estimate of farm numbers for 1992 is 2,094,000, a figure that includes CRP farms and Christmas tree farms, but excludes horse farms. The USDA estimate for 1994 is 2,044,000 farms.

[2] The definition of what constitutes a commercial farm varies by region and type of farm, as does the definition of what constitutes a part-time farm. Some farms with large sales probably are managed by operators who also manages off-farm enterprises and considers the farm enterprise as less than full-time employment. Alternatively, some farms with less than $20,000 of sales may engage the operator full time. For this study, we have arbitrarily divided farms into part-time (under $20,000 in sales) and commercial (more than $20,000 in sales) farms.

FIGURE 2-2: Farm Output by Farm Size



SOURCE U S Department of Agriculture, Economic Research Service (EC IFS 13-1), Economic Indicators of the Farm Sector, *Nationai Financial Summary 1993.*

isfy the nation's food and fiber needs is the result of large increases in land and labor productivity. Technical advances such as hybrid seeds, irrigation, fertilizer, and pesticides have raised crop yields and reduced the number of acres needed to satisfy agricultural markets. Larger machines can cover more acres and lower the amount of labor required, thus reducing the number of farmers needed. But that is not the whole story. Insect-resistant storage bins and chemicals to control rodents have reduced storage losses, and feed conversion rates for animal production have risen sharply, decreasing the amount of feedstuffs needed to produce meat. As yields and feed conversion rates went up and storage losses went down, farmers needed fewer acres to grow grain. As the sizes of machines increased and their numbers declined, fewer farmers were required to feed and clothe the expanding U.S. population, which grew by some 55 million people between 1970 and 1994. Even though export markets nearly doubled in volume over this period, crop production capacity still outdistanced markets, leaving on average some 55 million acres idle each year between 1984 and 1993.

Economic Status of Farm Households

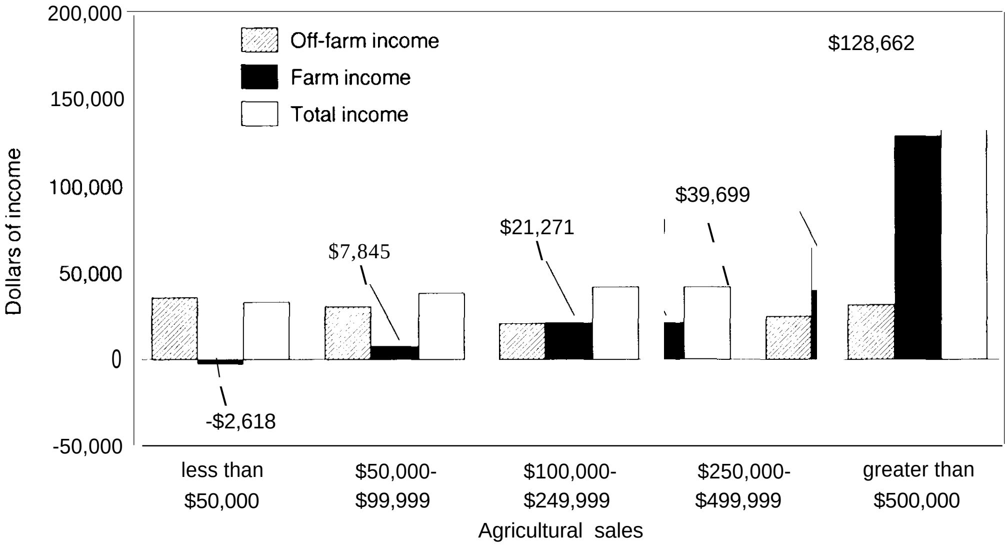
As the farm sector restructured itself, household income on both commercial and part-time farms rose significantly. Incomes rose on commercial farms as farming activities expanded and lowered per-unit costs of production on larger sales; and incomes rose on part-time farms as well, as family members found more work off the farm. The combination of higher farm incomes on commercial farms and higher off-farm incomes on part-time farms raised average incomes of all farm households. In 1993, for example, the U.S. Department of Agriculture (USDA) reported that average farm household income, from all sources, totaled $42,911 (22). For the same year, the Bureau of the Census reported that the average U.S. household had an income of $40,885 (29).

The data in figure 2-3 illustrate that farmhousehold incomes vary by farm size—and that the source of their incomes also varies. Generally, as farm size increases, farm income increases. For example, the amount of net farm income rises to $7,845 for farms selling between $50,000 and $99,999 worth of products annually, and reaches more than $128,000 on farms selling more than $500,000 worth of products annually. The essence of the farm situation today is that smaller farms earn most of their income off the farm, and actually lose money on their agricultural activities; larger farms make money from both their agricultural activities and employment off the farm.[3]

The low income from farming operations shown in figure 2-3 for intermediate-size farms ($50,000 to $99,999 worth of sales) leads many analysts to conclude that farm financial problems

[3] All farm income statistics cited are net of all expenses, including depreciation.

FIGURE 2-3: Farm Household Income 1993



SOURCE: U.S. Department of Agriculture, Economic Research Service (ECIFS 13-1), Economic Indicators of the Farm Sector: *National Financial Summary, 1993*

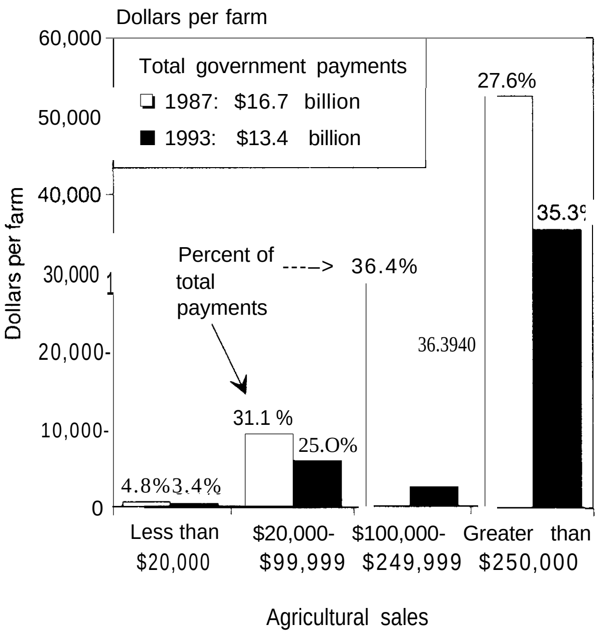
are concentrated primarily on this size farm. However, when income from sources off the farm is taken into account, these intermediate-size farms averaged household incomes of $38,309 in 1993, slightly under the average income of all U.S. households of $40,885 (29). As averages, both figures can hide wide variations in income. The data suggest, however, that when off-farm income is included in farm household income calculations, farms households are faring about as well as nonfarm households.

Variations in farm household income also result from differences in other organizational characteristics of farms. An important difference relates to borrowed capital. Some farms use large amounts of borrowed capital and have large interest payments. Others operate without borrowed capital and have low interest costs. Overall, the farming industry has a very low debt-to-asset ratio, averaging 16 percent in 1993 (15). Large farms (those with sales exceeding a half million dollars annually), have debt-to-asset ratios exceeding 25 percent (22); smaller farms have debt-to-asset ratios that range as low as 11 percent. However, as figure 2-3 indicates, the income of larger farms is much greater and it follows that debt repayment capacity is also larger.

Another measure of farm diversity is the rate of return on assets used in the farm business. Although large farms have high debt-to-asset ratios, those same farms have high rates of return on owned assets. For example, farms selling more than a million dollars of output annually have average rates of return of 25 percent according to one land grant university study (10). As farm size decreases, the rate of return declines to around 10 percent for farms selling between $100,000 and **$250,000** worth of products, and is negative for farms selling less than $40,000 worth of products annually.

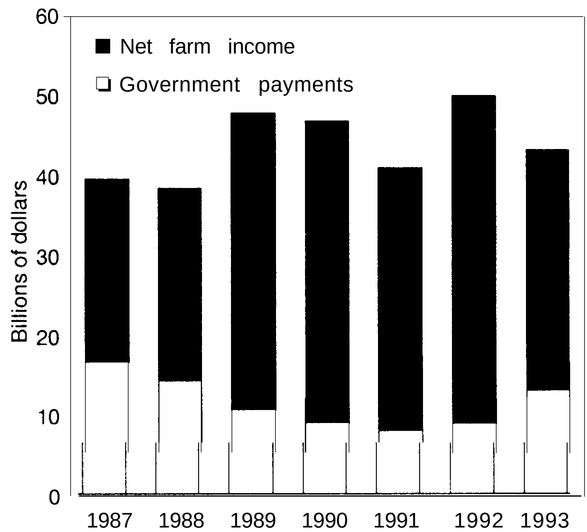
Government payments to farms also vary greatly, depending on farm size. Figure 2-4 divides farms into four size groups and shows the average payments to each group for 1987 and 1993. Direct payments made to farmers reached a high of $16.7 billion in 1987 and declined to $13.4 billion in 1992. The distribution of payments followed patterns of production with smaller farms receiving a

FIGURE 2-4: Government Payments by Farm Size



SOURCE: U S Department of Agriculture, Economic Research Service (EC IFS 13-1), Economic Indicators of the Farm Sector, *Nationai Financial Summary, 1993*

FIGURE 2-5: Net Farm Income and Government Payments



SOURCE: U.S. Department of Agriculture, Economic Research Service (EC IFS 13-1), Economic Indicators of the Farm Sector, *National Financial Summary 1993*

smaller share and larger farms receiving a larger share. Farms with sales under $20,000 annually received 4.8 percent ($593 per farm) of all direct payments in 1987 and 3.4 percent ($458 per farm) in 1993 (figure 2-4). Farms with sales of more than $250,000 received 28 percent ($52,557 per farm) in 1987 and 35 percent ($35,579 per farm) in 1993. Payments varied between these figures for farms with sales of more than $20,000 but less than $250,000 annually.[4]

The decline in direct government payments between 1987 and 1993 had little effect on net farm income. As figure 2-5 illustrates, net farm income was $39.7 billion in 1987 and $43.4 billion in 1993. The $3.3 billion drop in direct government payments between 1987 and 1993 was offset by a $33.2 billion increase in cash receipts and a $29.3 billion increase in cash expenses. The difference, *$3.9 billion,* covered the *$3.3* billion drop in payments, and contributed $0.6 billion of the $3.7 billion increase in net farm income. About half of the $33.2 billion increase in cash receipts was due to a rise in farm exports, which increasedby$14.1 billion between 1987 and 1993. The remainder was accounted for by increased domestic consumption, including more industrial uses of agricultural products and increased livestock sales.

Size and Diversity

Although individual farms may have undergone many changes in past years, the size and diversity of U.S. agriculture as a whole have remained the same. There are 2.3 billion acres (3,594,000 square miles) of open land outside the nation's cities—land that stretches from the irrigated valleys of California to the tile-drained lands of northern Iowa, from the windswept plains of western Kan-

[4]The European Union reports similar distributions of characteristics among its farms. See chapter 6.

TABLE 2-1: Total Land Area Land in Farms and Land Used for Crops

Year	Total land area	Total land in farms	Land available for crops	Land planted to crops	Land harvested for crops
	Millions of acres				
1970	2,264	1,063	384	333	289
1975	2,264	1,059	369	367	330
1980	2,264	1,038	382	382	342
1985	2,265	1,012	403	372	334
1990	2,265	987	403	341	310
1992	2,265	980	395	340	308
1993	2,265	978	391	332	299
1994	2,265	975	389	340	311

SOURCE: U.S. Department of Agriculture, Economic Research Service, *Agricultural Resources,* Situation and Outlook Report, AR-30, May 1993 and personal communications.

sas to the rolling pastures of Vermont and Maine. Across this vast expanse of land, farms accounted for 43 percent, or 975 million acres, in 1994. Yet these 975 million acres reflect a drop of over 85 million acres in farmland since 1970 (table 2-l). The downward trend in land available for farming was of widespread concern during the 1970s, as rising world food needs generated fears that science and technology would not provide sufficient output to offset the loss of cropland. But that concern slowly dissipated in the 1980s as production levels continued to rise, commodity exports declined, and large acreages of cropland again had to be idled under government farm programs.

Despite a decline in the amount of land in farms, land available for crops actually increased after 1975, rising from 369 million to over 400 million acres in 1985 before declining to 389 million acres in 1994. The increase came about as farmers plowed up grass and other types of noncropland and planted it with crops. Much of this expansion occurred in the 1970s, as an export boom increased economic returns. Some 30 million acres were added to the cropland base during this period (table 2-1). The expansion did not exhaust the supply of available acres. A 1975 study found that 111 million acres of land could be converted to crop production (27). A second study completed in 1977 found even more land, 127 million acres (28). However, this figure reflected a decline from the previous decade: in 1967, USDA's *Conservation Needs Inventory* had reported that 265 million acres could be converted (8). None of the studies specified what kinds of market prices would induce farmers to move more of these acres into crop production.

More important than land in farms, or even acreage available for crops, is the amount of land actually harvested. This measure of productive capacity varies more than land used for farms or land available for crops: it rises in good economic times (e.g., the 1970s) and falls in bad ones (the 1980s). By 1994, harvested acreage was down 30 million acres from what it had been in 1980. Many of these acres were drawn out of production by government-sponsored land retirement programs. In 1993, annual and long term land retirement programs removed over 56 million acres of cropland from cropping (table 2-2) while land harvested for crops was down 43 million from 1980. The 13-million-acre differential between the reduction in acreage harvested and the amount of acreage under government programs included land in the Conservation Reserve Program (CRP)[5] that had

[5]The CRP was authorized by the Food Security Act of 1985. It was intended to remove at least 45 million acres of erosion-prone land from production, and ensure that these acres would be used to plant grass or trees. More information on the CRP is provided in chapter 4.

TABLE 2-2: Federal Acreage Reduction Programs, 1975 – 1993

	Millions of acres idled, by commodity					
	Wheat	Feed grains	Cotton	Rice	Other	Total
Annual programs						
1980	0	0	0	0	0	0
1985	71	18,8	3.6	1,2	0	307
1990	75	171	2.0	1.0	0	27,7
1993	4,6	13,3	1.3	0.6	0	19.9
Conservation reserve program						
1980	0	0	0	0	0	0
1985	0	0	0	0	0	0
1986	0.6	0.6	0.1	0	0.7	2.0
1990	10,3	10,2	1,3	0	12.1	33.9
1993	109	11,0	1,4	0	13,2	36.5
Total acres idled						
1980	0	0	0	0	0	0
1985	7.1	18,1	3.6	1,2	0.7	30.7
1990	17.8	27.3	3.3	1,0	12,1	61.6
1993	15.5	24,3	2.7	0.6	13,2	56.4

SOURCE: U.S. Department of Agriculture, Economic Research *Service, Agricultural Resources,* Situation and Outlook Report, AR-32, October 1993

not been previously planted with program crops, and other acres that are often called slippage (i.e., cropland that might not have been planted if acreage reduction programs had not been in place). Examples include cropland pasture that went into the CRP, and areas around the edge of fields or along streams where tillage is difficult and the risk of machinery accidents is high.

Wheat and feed grains account for most of the acres removed from crop production by land retirement programs. In 1993, for example, 15.5 million acres of wheat land and 24.3 million acres of feed grain land were placed under government acreage reduction programs. An additional 3.3 million came from cotton and rice land. The total land idled was 56 million acres: 36 million acres in the CRP and 20 million acres in annual programs for wheat, feed grains, and other crops. The CRP retired almost equal amounts of wheat and feed grain acres: 10.9 million acres of wheat and 11.0 million acres of feed grains. Of widespread interest is what will happen to CRP acres when the 10-year contracts under which land is idled begin to expire in early 1996.

TECHNOLOGY AND MANAGEMENT PRACTICES

Acres idled under government programs are one important source of potential farm output. Another is technology. Technological innovation has played a significant role in transforming agriculture in the past, and still promises to have major impacts on the U.S. agricultural system. The transition from horsepower to mechanical power (1920 to 1950) boosted the productive capacity of agriculture even as farm labor requirements decreased dramatically. From 1950 to 1980, agricultural productivity rose further as irrigation, tillage practices, chemical fertilizers, and pesticides helped farmers to increase yields. Changed in how these technologies are used, which have been prevalent in the past decade, are discussed below.

■ Irrigation Water Use

Like the idled acres under government programs, irrigated cropland is of interest from an environmental standpoint. Irrigation can lead to so-called "intensive" farming: with a plentiful water supply, a fanner may use more fertilizer and other chemicals to get correspondingly higher levels of output. As fertilizer and pesticide use increases, the danger of runoff and seepage into underground waters and aquifers also increases.

Despite such problems, and the expense associated with its development, irrigation remains a key agricultural technology. In specialty crop production, irrigation is an insurance policy, protecting high-value crops against drought. In some instances, it also improves quality. Marketing specialists from the McDonald's Corp. recently pointed out that:

> Potatoes, particularly the type valued for the ubiquitous French fry, require more irrigation water, fertilizer and other chemicals than do many other crops. These requirements for potato growing have significant effects on production and management requirements (6).

With irrigation, the fast-food industry has the size and quality of potato that satisfies consumer demand for French fries. Without irrigation, it might have to develop other varieties.

The positive characteristics of irrigation led to a sharp increase in irrigated acres during the boom years of the 1970s. Compared with 39 million acres irrigated in 1969, some 50 million acres were irrigated by 1978 (table 2-3). Much of the additional output from the increased acreage went to overseas markets. When exports declined in the 1980s and farm income declined, the number of irrigated acres dropped, settling at 46 million acres in 1987. Subsequent improvements in agricultural markets led to another expansion in irrigated land, to 53 million acres in 1993. At that point, water for irrigation accounted for 81 percent of all fresh water used in the United States (18).

Along with the rise in the total number of acres irrigated, total water use for irrigation increased steadily during the 1970s. After 1980, water use for irrigation stabilized, reflecting fewer acres irrigated and a decline in per-acre use, from 2.09 ft / acre in 1970 to 1.80 ft/acre in 1993. New irrigation techniques helped farm operators find more efficient ways of using irrigation water—a trend that

USDA, ARS

Irrigation scheduling and uniform distribution are key factors in improving irrigation management and reducing agrichemical losses. Shown here is a center pivot irrigation system that provides water for nearly 270 acres of corn.

bodes well for the growing water demands of cities and instream uses. (See chapter 4.)

■ Tillage Methods

Along with using irrigation water more efficiently, farmers have found new ways to till their cropland. In some instances, the motivation to use new tillage methods is economic: these practices can lower production costs for many farmers (2). In other cases, the incentive is eligibility for farm program payments. Under the Food Security Act of 1985, commonly known as the 1985 farm bill, farmers with land especially prone to erosion were required to have a conservation plan in place for their farms by January 1, 1995, or possibly lose

TABLE 2-3: Irrigated Acreage by Regions of the U.S., 1975-1993

Region	Millions of acres 1869	1978	1987	1900	1993
Atlantic seaboard	1.8	2.9	3.0	3.4	3.4
Corn belt & lake states	0.5	1.4	2.0	2,2	2.7
Northern plains	4.6	8.8	8.7	9.8	10.6
Delta states	1.9	2.7	3.7	4.6	5.4
Southern Ppains	7.4	7.5	4.7	5.5	5.3
Mountain	12.8	14.8	13.3	14.6	14.5
Pacific	10.0	12.0	10.8	11.4	10.8
Total	39.1	50.4	46.4	51.6	52.8

SOURCE:U.S. Department of Agriculture, Economic Research Service, *Agricultural Resources,* Situation and Outlook Report, AR-30, May 1993;

program benefits. Through 1992, loss of farm program payments for violations of conservation provisions (often called Sodbuster provisions) had been relatively small: $6.4 million on 129,000 acres (18). However, as late as 1993, a total of 55 million acres out of the 148 million acres designated by the Soil Conservation Service (SCS) as "highly erodible" were subject to a conservation plan that was not fully applied or not yet certified. Another seven million acres were not under any conservation plan, either because producers had not requested such a plan from SCS or had not accepted a proposed conservation plan (18). These numbers suggest that up to 62 million acres might have been ineligible for program payments on January 1,1995, when conservation plans were required.

Conservation tillage provides many advantages for farmers and the environment. It is being adopted by more farmers each year

One way for farmers to meet conservation requirements and maintain their eligibility for farm program payments is by adopting "conservation tillage" practices. (For an explanation of conservation tillage, see box 2-1.) Corn and soybeans, two crops that leave land susceptible to wind and water erosion, illustrate the rapid rate of adoption. Twenty-one percent of corn acres were farmed using conservation tillage in 1988 and 39 percent in 1992 (table 2-4). Soybean production went from 16 percent using conservation tillage in 1988 to 37 percent in 1992. Wheat has shown a smaller increase. Nineteen percent of the 1988 wheat crop was produced with minimum tillage, and 25 percent in 1992. One explanation for conservation tillage's apparent lack of popularity in the wheat sector is that wheat growers have long used fallow systems that maximize moisture retention. The new tillage systems are similar to those already used by wheat growers (with the exception of no till, and production of wheat using the no-till method has increased). For rice and cotton, the major change has been the substitution of other conventional tillage methods for methods that used the moldboard plow. Use of the moldboard plow in cotton decreased by half between 1988 and 1992. The moldboard plow had not been widely used in rice production for sometime, but even in this sector farmers are using it less. Nationally sales of new moldboard plows consequently dropped from 60,543 in 1974 to only 1,382 in

BOX 2-1: Conservation Tillage

Conservation tillage is defined as any tillage and planting system that (a) leaves at least 30 percent of the planted soil surface covered by residue to reduce soil erosion by water, or (b) leaves at least 1,000 pounds of residue per acre during critical periods when soil erosion by wind IS a primary concern. Two key factors influencing the amount of crop residue are the type of crop previously harvested and the type of tillage operations carried out before and during planting. There are three types of conservation tillage practices:

1. No Till, The soil is left undisturbed from harvest to planting, except for nutrient injections. Seeds are planted in a narrow bed or slot created by coulters, row cleaners, disk openers, in-row chisels, or roto-tillers. Cultivation may be used for emergency weed control.
2. Ridge Till. The soil is left undisturbed from harvest to planting, except for nutrient injection. Seeds are planted in abed prepared on ridgeswith sweeps, disk openers, coulters, or row cleaners. Residue is left on the surface between the ridges. Weeds are controlled with herbicides and/or by cultivation. The ridges are rebuilt during cultivation.
3. Mulch TiIl. The soil is broken before planting with tillage tools such as chisels, field cultivators, disks, sweeps, or blades. Weeds are controlled with herbicides and/or by cultivation.

Other types of tillage and planting systems that leave less than 30 percent of the soil's surface covered by residue may meet erosion control goals with or without other supporting conservation practices (for Instance, strip-cropping, contouring, or terracing).

SOURCE: USDA/ERS, May 1993, p 31

1991, reflecting a dramatic change in less than two decades (14,15).

As the use of conservation tillage has increased, horsepower requirements on farms have changed. Annual sales of large tractors (those with more than 99 hp) peaked in 1990 at 22,800 units and declined 11 percent by 1994 (table 2-5). Sales of extra-large, four-wheel-drive tractors dropped sharply. Sales of smaller tractors were more stable.

Conservation tillage uses less fuel as well as less horsepower. Gasoline use on farms has declined strikingly, from 2.9 billion gallons in 1981 to 1.6 billion gallons in 1992. Diesel fuel use declined slightly, and the use of liquid petroleum gas was cut by a full 40 percent (17). Even though some of the reduction may be attributed to more efficient and increased amounts of custom services, the clear inference is that conservation tillage has reduced the amount of fuel used on farms. The effect on labor use has been less dramatic. Total hours of contract and hired labor used on farms declined about 8 percent between 1981 and 1991. Taken together, lower fuel use and decreased labor requirements resulted in lower production costs. One Ohio study estimated that a shift to no-till methods reduced production costs by $20 per acre, compared with the costs of conventional tillage practices. The same study found that substituting a chisel plow for a moldboard plow reduced production costs by $8 per acre (2).

Fertilizer and Pesticide Use

Applications of fertilizer declined after 1981, as farm programs drew land out of production and weaker markets reduced farm incomes. In 1983, when planted acreage was reduced by nearly 50 million acres in an attempt to lower stockpiles, fertilizer use dropped nearly 25 percent. Fertilizer applications increased again in 1984, but not to previous highs, as crop acreages expanded to offset the effects of a drought in 1983 and government programs. These lower usage levels reflect a sharp reversal of earlier trends. Total use rose from 7.5 million nutrient tons in 1960 to

TABLE 2-4: Tillage Systems Used in Crop Production, 1988 to 1992

Crop and tillage system	1988	1989	1990	1991	1992
Corn (million acres)	53.2	57.9	58.8	60.4	62.9
No till (percent)	7	5	9	10	12
Ridge-till	*	*	*	*	2
Mulch-till	14	17	18	20	25
Conv/wo/mbd plow[a]	20	59	57	55	49
Conv/w/mbd plow[b]	20	19	17	15	12
Soybeans (million acre)	48.8	50.9	48.2	49,2	48,6
No till (percent)	4	6	7	10	14
Ridge-till	*	*	*	*	1
Mulch-till	12	16	18	21	22
Conv/wo/mbd plow	62	58	57	55	53
Conv/w/mbd plow	22	20	18	14	10
Wheat (mill Ion acres)	45,1	54.3	59.1	50.7	56.5
No till (percent)	1	1	3	3	4
Mulch-till	18	21	19	21	21
Conv/wo/mbd plow	66	65	67	66	65
Conv/w/mbd plow	15	13	11	10	10
Rice (million acres)	2.1	2.1	1.8	1,9	2.0
No till (percent)	*	*	1	2	1
Mulch-till	2	*	3	4	4
Conv/wo/mbd plow	96	97	96	94	95
Conv/w/mbd plow	2	1	1	*	*
Cotton (million acres)	9.7	8.4	9.7	10.9	1 0 2
No till (percent)	*	*	1	1	*
Mulch-till	*	*	1	1	*
Conv/wo/mbd plow	72	84	84	76	88
Conv/w/mbd plow	28	15	14	21	12

[a]Conventional without moldboard plow
[b]Conventional with moldboard plow
*Included in no-till for these years

SOURCE: U.S. Department of Agriculture, Economic Research *Service, Agricultural Resources,* Situation and Outlook Report, AR-29, February 1993

TABLE 2-5: Numbers of Tractors Purchased, 1966-1994, by Size and Type

Year	40-99 hp	>99 hp	4-wheel drive	Total tractors sold
1986	**30,800**	14,300	2,000	47,100
1987	**30,700**	15,900	1,700	48,300
1988	**33,100**	16,100	2,700	51,900
1989	**35,000**	20,600	4,100	59,700
1990	**38,400**	22,800	5,100	66,300
1991	**33,900**	20,100	4,100	58,100
1992	**34,600**	15,700	2,700	53$000
1993	**35,500**	19,000	3,300	57,800
1994	**39.100**	20,400	3,700	63,200

SOURCE: U.S. Department of Agriculture, Economic Research Service, *ARE/ Updates Farm Machinery, No.* 1, 1995

TABLE 2-6: Fertilizer Use in the United States, 1960-1993

Year	Nitrogen	Phosphate	Potash	Total
	Millions nutrient tons			
1960	2.7	2.6	2.2	7.5
1970	7,5	4,6	4.0	17.2
1980	11,4	5,4	6.2	23.1
1985	11,5	4,7	5.6	21.7
1990	11.1	4 3	5.2	20.6
1991	11,3	4 2	5.0	20.5
1992	11,4	4,2	5.0	20.6
1993	na	na	na	19,8

SOURCE U S Department of Agriculture, Economic Research Service, *Fertilizer Use and Trade,* March 1993

16.1 million tons in 1970, and continued upward thereafter, reaching a high of 23.1 million tons in 1980 (table 2-6). By 1993, however, fertilizer applications totaled 19.8 million short tons, down 14.3 percent from 1980.

The dip in fertilizer use to below 20 million tons in 1993 may have been a temporary phenomenon, reflecting that year heavy rains and flooding. What may be more permanent is the pressure on growers to reduce all kinds of chemical use in farming. Concerns over environmental impacts have subjected all agricultural chemicals to new and more intense scrutiny. (See chapter 4.) Coupled with intense cost pressures that force growers to reduce inputs wherever possible, all chemical use has stabilized or fallen.

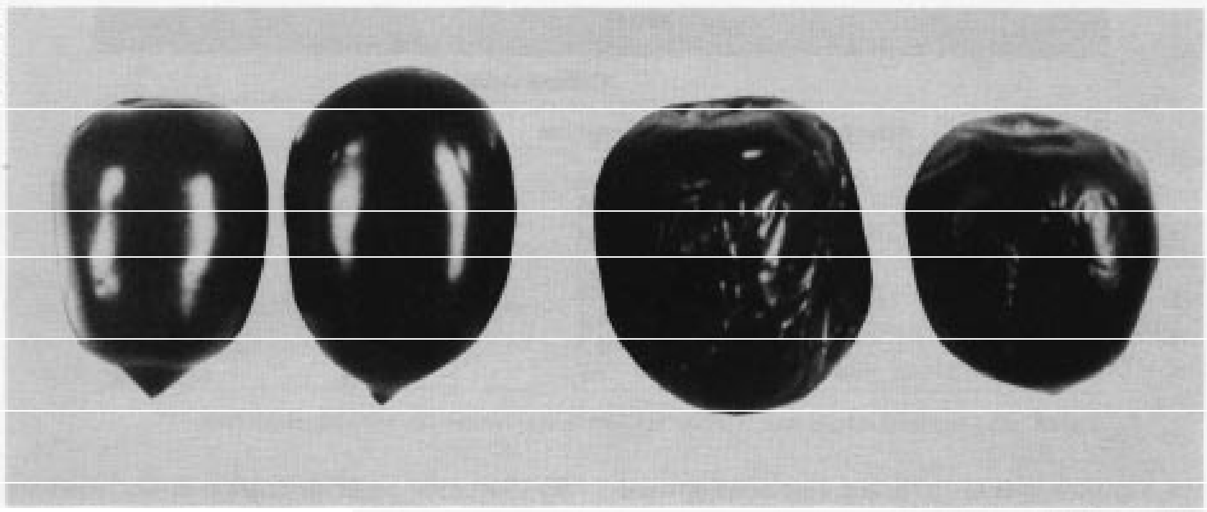
The pattern of pesticide use mirrors that of fertilizer use: rising sharply in the 1970s, peaking in the early 1980s, and dropping sharply thereafter. By 1990, total pesticide use was down 13 percent from the record set in 1982 (table 2-7). Pesticide use declined in 1993 by an estimated 3 percent (17). Trends in use of individual pesticides have varied. Herbicide use expanded rapidly in the 1960s and 1970s, peaked in 1982 and then eased downward. Insecticide use was relatively steady from 1964 through 1976 and then dropped off sharply. Fungicide use was relatively stable throughout the period. Corn production accounted for the greatest percentage of pesticides used in U.S. agricultural production (43 percent in 1992), in part because corn is planted on more acres than any other crop. Soybean production accounted for 12 percent of pesticide use; cotton, for 10 percent; and potatoes, for 7 percent. Wheat, grain sorghum, and rice accounted for about 3 percent each; peanuts and citrus fruits, for 2.5 percent each.

TABLE 2-7: Estimated Quantities of Pesticides Applied to U.S. Crops, Selected Years 1964-1992

Years	Herbicides	Insecticides	Fungicides	Other pesticides	Total pesticides
	Quantities applied to crops (1,000 pounds)				
1964	54,884	128,167	21,715	27,983	232,750
1966	87,351	121,717	21,660	24,233	254,961
1971	198,949	137,808	30,906	31,565	399,228
1976	368,422	135,920	29,546	31,072	564,960
1982	464,596	84,793	27,519	35,417	612,325
1990	376,363	56,617	31,632	68,958	533,571
1991	368,269	51,055	33,117	80,900	533,341
1992	387,126	56,837	34,242	85,657	563,863

SOURCE: USDA/ERS, Unpublished Data, May 1994

CALGENE, INC.



Genetically engineered tomatoes, approved by the FDA in 1994 (left), and control (right) 3 weeks after harvest.

The decline in pesticide use between 1982 and 1992 may continue. Public and government pressure on agricultural producers to work in greater harmony with nature—that is, to practice "sustainable agriculture''-already has induced many to change their farming practices, as noted above. With regard to such inputs as fertilizers and pesticides, the overuse that characterized the farming of decades past was called into question during the economic downturn of the 1980s. Upon close examination, reduced levels of inputs often were found to offer lower costs with little or no loss in yields. In addition, a generation of new and more effective pesticides has helped lower usage levels (although not necessarily costs). As future farm prices and incomes remain uncertain, especially on smaller and moderate-size farms, input use will, in all likelihood, be monitored closely to hold down production costs.

■ A New Generation of Technology

Change certainly has taken place in how current technologies are used. But change is also taking place in the types of technologies that will be used in the future. Today, U.S. agriculture is on the threshold of a new era: the biotechnology and information technology era. Technologies that have just been introduced, or are in the final stages of development, have the potential to increase agricultural productivity, enhance the environment, and improve food safety and quality. Some of the major technologies that will be influential in the future are outlined below.

■ Biotechnology

Biotechnology, broadly defined, includes any technique that uses living organisms or processes to make or modify products, improve plants or animals, or to develop microorganisms for specific uses (12). It relies on two powerful molecular genetic tools: recombinant deoxyribonucleic acid (rDNA); and cell fusion technologies. Using these tools, scientists can isolate, clone, and study the structure of an individual gene, as well as explore the gene's function. Such knowledge allows scientists to exercise unprecedented control over biological systems, leading to significant improvements in agricultural plants and animals.

Some of the new technologies are or will soon be on the market. For example, in early 1994, the U.S. Food and Drug Administration (FDA) approved the first genetically engineered tomato, which has an extremely long shelf life and a better flavor than many tomatoes currently available to consumers. The tomato may be harvested ripe for full flavor, shipped without refrigeration, and delivered fresh to supermarket shelves without the standard ethylene "gas" treatment.

Genetic engineering allows scientists to breed plants that have greater resistance to disease, insects, and weeds, and can withstand environmental stresses such as cold, drought, and frost. It also allows them to develop value-added products from agricultural commodities; and to improve their understanding of plant resistance and of the interactions among plants, pests, and biological control agents in the agro-ecosystem.

Insect Control

Traditional breeding programs have produced, and will continue to produce, insect-resistant or insect-tolerant varieties of crops. However, the tools of biotechnology can be used to selectively engineer plants for this trait. For example, genetic coding for bacterial Bacillus thuringiensis (Bt) toxin has been cloned and inserted into plants.[6] Transgenic plants producing Bt toxins are expected to be commercially available by the mid to late 1990s.

Weed Control

Improved understanding of how herbicides work is helping scientists to design herbicides that destroy some plants (e.g., weeds) but have no effect on others (e.g., crops). In addition, genetic engineering is being used to develop crops that have some resistance to herbicides. The frost herbicide-tolerant crops are expected to be commercially available by the mid-1990s.

Disease Control

Biotechnology techniques are being employed to determine how pathogenic organisms cause disease and to engineer plants that can better resist disease. Genetically engineered plants that resist certain viruses are expected to be commercially available by the mid- 1990s. In animal agriculture, biotechnology has the potential to improve feed efficiency, reduce losses from disease, and increase the ability of all livestock to reproduce successfully. Advances focusing on growth promotants, reproductive technologies, and animal health will play a major role in enhancing the efficiency of animal agriculture and the quality of its products.

Growth Promotants

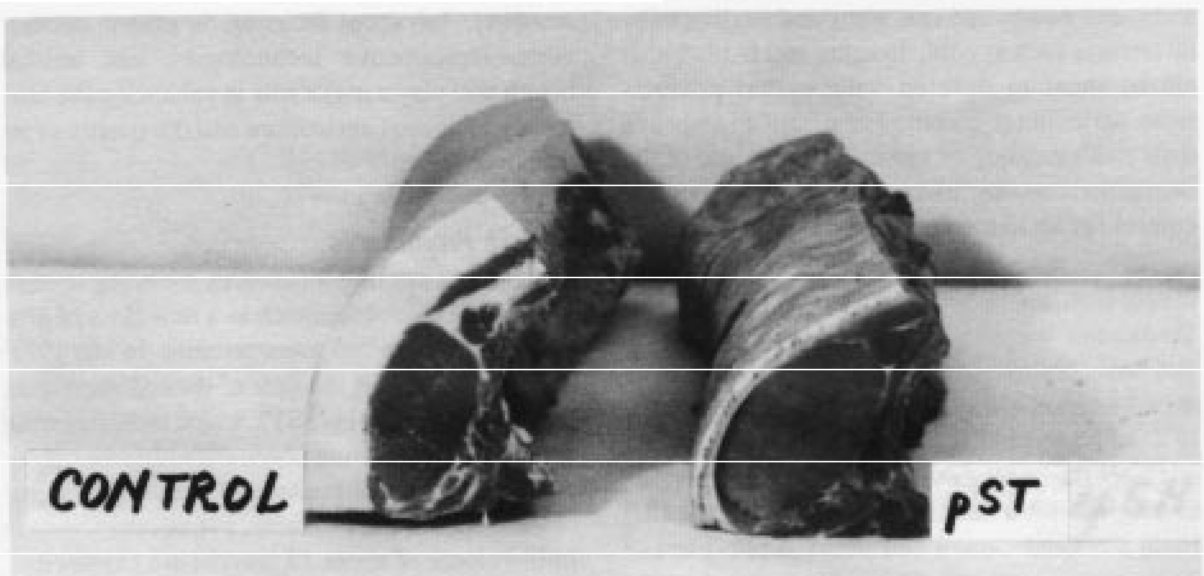
Genetic engineering techniques are being used to produce new products such as a new class of protein hormones called somatotropins. In late 1993, the FDA approved the first of these compounds, bovine somatotropin (bST), which increases milk production in lactating cows. Although the efficacy of the product ultimately relies on the management ability of the producer, average increases in milk volume of about 12 percent are expected.

Another growth promotant, porcine somatotropin (pST), is expected to be approved for use in the near future. Pigs that are given pST show increases in average daily weight gains of approximately 10 to 20 percent, improved feed efficiency of 15 to 35 percent, decreased fat tissue of as much as 50 to 80 percent, and concurrently increased protein deposits of as much as 50 percent. The quality of their meat is not adversely affected.

Tomato plants that show one -stripped by caterpillar and one not. The plant not stripped contains the Bacillus thuringienis toxin gene.

[6]Bt is a spore-forming bacterium that produces insecticidal proteins. Different strains of Bt produce proteins toxic to different insects. Through biotechnology insecticidal genes from different Bt strains have been incorporated into other organisms, including plants, which then produce the corresponding Bt toxin.

TERRY ETHERTON, PENNSYLVANIA STATE UNIV.



Comparison of pork loins that show the effect of pigs treated with porcine somatotropin (pST). The loin-eye area of the loin treated with pST is 8 square inches; the control is 4.5 square inches.

Animal Reproduction Technologies

The field of animal reproduction is undergoing a scientific revolution. In the cattle industry, for example, it has become possible to induce genetically superior females to shed large numbers of eggs; and to fertilize these eggs in vitro with the sperm of genetically superior males. Each resulting embryo can be sexed (i.e., preselect the sex of the embryo) and split to produce multiple copies of the original embryo. Each of the new embryos can then be frozen for later use, or transferred to a recipient cow. The cow carries the embryo to term and gives birth to a live calf. It maybe possible in the near future to sex the sperm rather than the embryo, or to create more copies of each embryo than is currently possible.

USDA, ARS

Animal physiologist prepares embryo for microscopic examination before implanting it into an animal.

Animal Health Technologies

Biotechnology is rapidly acquiring a prominent place in veterinary medical research. New vaccines include those created by deleting or inactivating the genes in a pathogen that cause disease. The first gene-deletion viral vaccine to be approved and released for commercial use was the pseudo-rabies virus vaccine for hogs.

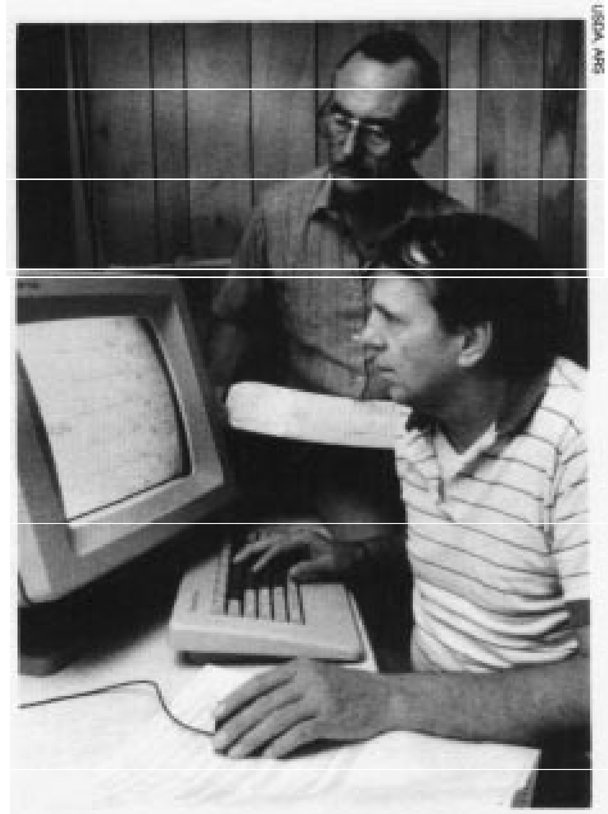
■ Advanced Computer Technologies

Since the Industrial Revolution, agricultural systems have intensified, and agricultural productivity has grown significantly with farm size. Labor-saving devices on farms have increased output per worker many times over, and advances in understanding and applying biological principles have boosted agricultural yields significantly. As production has increased, however, managing a farm has becomes a more challenging and complex job. Even today, many farmers make decisions with less than full information, and many agricultural systems are poorly managed (12).

Advanced computer technologies can make for more effective agricultural management. Computer technologies can provide managers with the ability to determine systematically the best decision, rather than arrive at decisions in an ad hoc fashion. For example, a farmer deciding whether to plant a specific crop on a specific field can weigh the profitability of the crop, as well as overall farm needs (e.g., nutritional requirements for livestock). The decision will have an impact on land sustainability, and will determine whether certain pest-control strategies should or should not be used. Improved access to information can also help farmers to monitor their progress more effectively. Keeping better track of animals' growth rates, for instance, can allow a farmer to detect diseases earlier.

The primary application of computer technology by the mid to late 1990s will be so-called expert systems (i.e., computer programs that actually solve problems, based on information given to them). Such systems are currently being developed, and farmers will have a cadre of them to diagnose diseases and to evaluate production performance. These systems generally will not be integrated with one another: each will consider only one aspect of a problem. Integrated systems that solve production problems while considering economic and environmental consequences will not be available until the latter part of the decade.

Electronic sensors are already playing an important role in agriculture. Sensors are being used for improving operations in crop production by machine guidance systems, applying pesticides and fertilizers more accurately, and improving the management of irrigation water to conserve there-source and reduce production costs. Current research focuses not only on developing methods of monitoring crop growth that can be used with computer models for improving day-to-day crop management and strategic planning, but also on developing sensors for assessing crop maturity and fruit location as a basis for mechanical harvesting. Sensors and satellite technology are currently used to monitor weather and field conditions for crop management. Expert systems help farmers to interpret these data and suggest appropriate management strategies for irrigation, fertilizer, or pesticide treatments.


USDA ARS

Farmer and consultant examine data from a expert system that has diagnosed a crop disease on his farm and provided the specific remedy based on the unique characteristics of his farm.

DOMESTIC MARKETING TRENDS

Beyond the farm gate, the process of turning farm commodities into finished food products also has changed. Fresh fruits and vegetables that once were picked in the fields and transported to packing sheds and then to market are now packed in the field and transported directly to retail markets. Milk that once was shipped to local processing plants is now refrigerated and shipped to urban processing centers. Chickens that once were grown in small flocks on farms for supplemental income are now raised in specialized broiler facili-

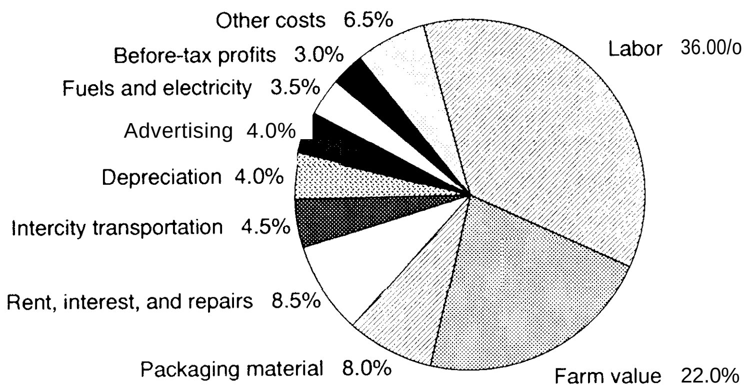
The combination of sensors, global positioning systems and expert systems allow site-specific programs to be developed such as for crop nutrient management.

ties and processed by the hundreds of thousands daily. Small comer grocery stores that were once the mainstays of families throughout America have slowly lost ground to large supermarkets—and supermarkets have in turn lost some ground to specialized stores catering to health food aficionados, the elderly, or other niche markets.

The economic components of the food chain have also changed. Processing and retailing costs now account for 78 percent of the nation's food bill (and farm value 22 percent). Of that 78 percent, labor costs make up 36 percent; packaging materials, 8 percent; intercity transportation, 5 percent; fuel and electricity, 4 percent; and corporate profits, 3 percent. Other costs, such as interest, depreciation, and advertising, account for the remaining 22 percent (20) (figure 2-6). In return for the added processing and marketing costs they pay, consumers are able to spend less time preparing food and more time doing other things, including eating out in restaurants. Restaurant meals accounted for 45 percent of all food dollars spent in 1992, a substantial increase from the 25 percent spent in 1954 (3).

New ways of organizing food production in the United States are being introduced at a relatively rapid rate, spurred by high rates of return on capital, declining levels of economic protection from government farm programs, and other forces. These trends have the potential to change marketing practices for a wide range of crop and livestock production. This section focuses on some specific marketing methods that are already widely used in agricultural production.

FIGURE 2-6: Economic Components of Food $: 1993



Total 1983 costs: $217.5 billion
Total 1993 costs: $382.1 billion

SOURCE: U.S. Department of Agriculture, Economic Research Service, *Food Cost Review,* 1993, Agricultural Economic Report No 696, Washington, DC, August 1994

Contract Production and Vertical Integration

As consumer demand for high-quality agricultural products has increased, agricultural marketing has moved more toward coordinating production methods and final market demand. As a result, more farmers are working under contract to processors—that is, they produce specialty crops and some types of livestock according to the terms of a written agreement. Similarly, vertical integration (which means that a single firm handles the different functions of production, processing, marketing, and retailing) is becoming more and more common in agriculture, accounting for a larger share of processed vegetables, fresh vegetables, and potatoes (table 2-8). Production for sale into open markets, where the producer delivers the product to a middleman who then moves it to the ultimate consumer, is less the rule.

Vertical production and contract production are becoming more prevalent in animal agriculture. Turkey production, like broiler production, involves more contract production and less production for open markets. Production of eggs and even sheep and lambs is following suit. Large-scale, integrated operations for hog production are replacing traditional corn-hog production. Alan Barkema of the Federal Reserve Bank in Kansas City reports that "from 1980 to 1990, the percentage of the nation's hog production under contract or vertical integration doubled to about 10 percent." He notes that other estimates place this share as high as 16 percent in 1991 (4). Notably bucking the trend is cattle feeding—a lower percentage of output involved contracts and vertical integration in 1990 than in 1970.

Field crops continue to be sold mostly through open markets, although contractual arrangements are accounting for a larger share of food and feed crops. No figures are available for oilseeds, but the trend is likely to be similar to that for other field crops. Michael Cook, an economist with the University of Missouri, offers four explanations for this growing phenomenon in grain markets:

> First, consumers have become more discriminating buyers not only of grain products, but of all products including grain and oilseed-based items. Second, biological, mechanical, and chemical technology is beginning to permeate the grain related industries, permitting participants to evaluate risks and consumer needs in greater depth. Third, the demand for organizational forms that minimize the information

TABLE 2-8: Farm Products Marketed Through Contracts, Integrated Ownership, and Open Markets in 1970 and 1990

	Form of marketing					
	Contracts		Vertical integration		Open markets	
Commodity	1970	1990	1970	1990	1970	1990
Field crops						
Food grains	2	7	1	1	97	92
Feed grains	1	7	1	1	98	92
Cotton	11	12	1	1	88	87
Specialty crops						
Processed vegetables	85	83	10	15	5	2
Fresh vegetables	21	25	30	40	49	35
Potatoes	45	55	25	40	70	95
Citrus	55	65	30	35	15	0
Other fruit	20	40	20	25	40	65
Livestock						
Broilers	92	92	7	8	1	0
Turkeys	60	65	12	28	28	7
Hatching eggs	70	70	30	30	0	0
Market eggs	35	43	20	50	45	7
Manufactured milk	25	25	1	1	74	74
Hogs	1	18	1	3	98	79
Fed cattle	18	12	7	4	75	84
Sheep/lambs	7	7	12	33	81	60

SOURCE: Patrick M O'Brien, "Implications for Public Policy, " in National Planning Association, *Food and Agricultural Markets: The Quiet Revolution,* Lyle P. Shertz and Lynn M Daft (eds.), Washington, DC, 1994, p 301

search and monitoring costs of operating in a more segmented and higher technology marketplace is increasing. Fourth, an over expansion in physical assets with few alternative uses created financial burdens on many participants that required better risk-management tools (5).

Cook concludes that agricultural markets are moving toward two markets: one a market in which grain and oilseeds will be traded for traditional purposes, like livestock feed or industrial uses, and a second in which commodities are purchased for specialized uses such as food processing, pharmaceutical uses, and cosmetic applications. Cook titles the former a "commodities" market and the latter a "products" market.

Industrial Uses of Farm Commodities

In addition to consumer demand for quality, industrial demand for farm commodities is encouraging shifts to contract farming. To keep production lines running smoothly, industrial firms require a steady, uniform supply of raw materials. When agriculture becomes the source of raw materials, its greater variability in quality and quantity must be addressed. Generally, this can be done through contractual arrangements between growers and industrial firms that ensure uniformity in, and constant supplies of, a material. Such arrangements are even more likely to be employed if the industrial crop in question is new and grown on relatively small acreages, as many industrial crops are.

Although some analysts forecast a rosy future for industrial crops, the expansion starts from a small base, which limits the overall impact on demand. In 1991, an OTA report concluded that "[l]arge-scale replacement of U.S. fuel use or primary chemical feedstocks would require significant acreage for crop production. However, economics do not favor these developments at the current time" (11). The president of the American Farm Bureau Federation touted the virtues of industrial crops three years later—but also was careful to couch his remarks in terms of the future, not the present:

> Alternative uses of major farm commodities are attracting attention (for example, ink made from soybeans). Improvements will lead to greater use, eventually requiring 100 million bushels of soybeans to meet annual demand. Corn growers eagerly promote ethanol use because it adds 20 cents to their pockets for every bushel of corn sold. Ethanol, packing materials, and other industrial uses of corn could require 850 million bushels a year. Paints, fiberboard and medicines could also contain farm products. Many more alternative uses will occur and will contribute to a farmer's income (7).

Retail Food Marketing Changes

As the nation's population gradually ages, as two-income families have less time to prepare food at home, and as nutrition and food safety become ever more important to consumers, retailers are providing a constant stream of new products, new forms of packaging, and new market outlets. The elderly, for example, want food products that meet special dietary needs. Working parents want foods that can be prepared quickly but are nutritious, and health-conscious consumers want foods that are low in fat and high in energy. The retailers' response can be seen in more salad bars in full-line food stores, and more take-out sections in gourmet food stores, to cite only two examples. As Barkema has observed, "consumers are becoming more discriminating, requiring the food industry to design its products more carefully" (4).

In 1991, Senauer, Asp, and Kinsey pointed out that "[s]ome consumers are willing to pay a premium for products such as free-range chickens, natural beef raised without antibiotics or hormones, or wild game meat that is raised for sale" (9). With consumers willing to pay, processors have established contracts with growers that ensure that supplies of specialty items will be available. In the 1980s, these items translated into big business. Senauer, Asp, and Kinsey, estimate that sales of organic products—that is, products grown without chemical pesticides or synthetic fertilizer and distributed without artificial preservatives or dyes—amounted "to over $3 billion annually."

GLOBAL MARKETING TRENDS

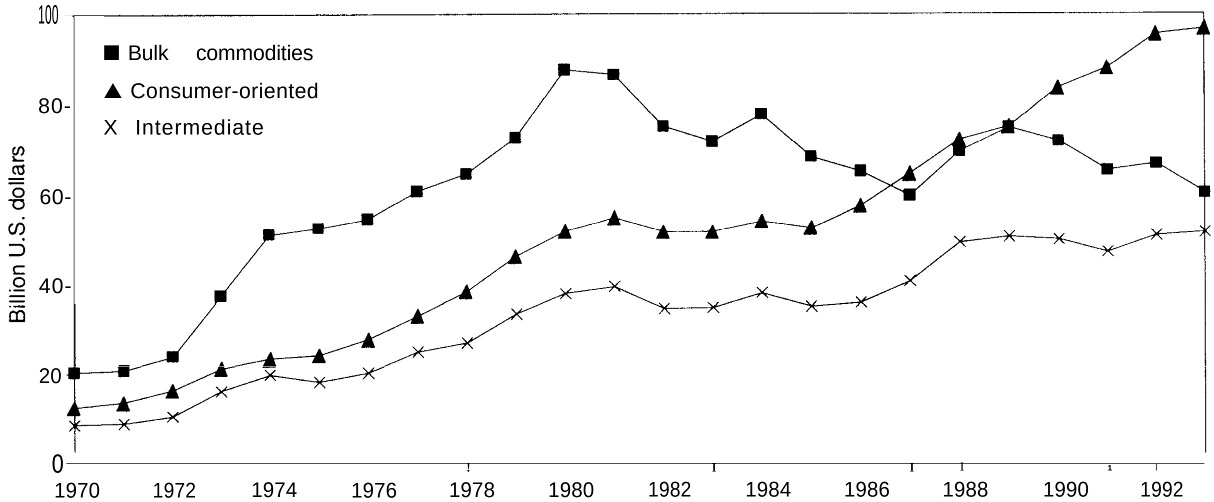
Global markets for agricultural goods are changing as much as domestic markets. On the one hand, certain developing countries have applied new agricultural technologies that have improved their crop yields, increased their degree of self-sufficiency, and decreased their need for imports.[7] On the other hand, international trade agreements have helped to open up international agricultural markets and increase exports. Following the Tokyo Round of the General Agreement on Tariffs and Trade (GATT), which ended in 1979, negotiations to expand trade in food products continued, and were ultimately successful. Another strong force pushing expanded global food trade has been the economic prowess of Pacific Rim countries. As they have modernized and expanded their economies, and as their trade surpluses have grown, these countries have gradually opened their markets to imports of semiprocessed and retail-ready food products.

Value-Added Food Trade

The impact of all these changes can be seen in the changing composition of global food trade. The higher yielding crops grown in developing countries lowered imports and reduced trade in bulk commodities. Higher incomes and lower trade barriers brought more trade in intermediate and

[7]Bangladesh exemplified the trend, with high-yielding varieties (HYV) used for 1.6 percent of all wheat planted in 1967-68 and 95.9 percent in 1982-83. In India, 4.2 percent of all wheat planted used HYV in 1966-67 and 76.0 percent in 1983-84. China increased from 10.1 percent HYV in 1980 to 34.2 percent in 1984, an amazing increase in such a short period (1).

FIGURE 2-7: World Agricultural Trade by Type



SOURCE: U.S. Department of Agriculture, Foreign Agricultural Service, *Desk Reference Guide to U.S. Agricultural Trade,* Agricultural Handbook *No 683,* revised April 1994

consumer-oriented food products.[8] The shift began in the early 1980s, at the same time that U.S. exports of bulk commodities began to decline. Initially, the prevailing explanation for declining exports of bulk commodities was that higher price supports in the 1981 farm bill, along with a stronger dollar and a weak global economy, made U.S. commodities uncompetitive in global markets. As global trade continued to shift toward more value--added trade (i.e., trade in both intermediate and consumer-oriented products) and less bulk commodity trade, the explanation began to change. B y 1989, the USDA's Foreign Agricultural Service (FAS) reported that:

> During the 1980s, growth in world trade was greatest in consumer-oriented products, which grew by around 3 percent, or $3.7 billion a year, compared to less than 1 percent a year for both bulk and intermediate products.

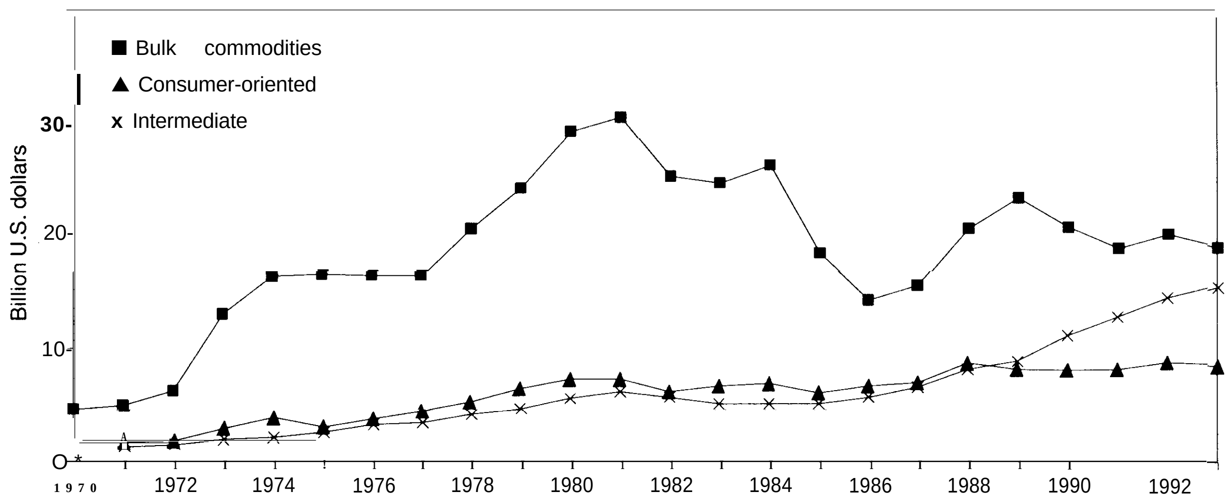
The report noted that:

> Increases in demand were most concentrated in meats, horticultural products, dairy products, beverages and pre-packaged food preparations (23).

What was unclear in the early 1980s was that expanding demand for value-added food items was changing the overall composition of world food trade. The share of global food trade accounted for by consumer-oriented food products rose 12 percentage points between 1980 and 1990, from 30 to 42 percent, and the share accounted for by intermediate food products increased 3 percentage points, from 21 to 24 percent. The share accounted for by bulk commodities fell by 15 percentage points, from 49 percent to 34 percent. (For more recent trends, see figure 2-7.) A small portion of the increased trade in consumer-oriented

[8] Bulk commodities are products that have not been processed, such as wheat, corn, rice, soybeans, and unmanufactured tobacco. Intermediate products are semiprocessed products, such as wheat flour, oilseed meal, vegetable oil, hides and skins, animal fats, wool, and refined sugar. Consumer-oriented products are end products that require little or no additional processing for consumption, such as fresh and processed horticultural products, fresh and processed meats, dairy products, table eggs, and bakery products.

FIGURE 2-8: U.S. Agricultural Exports by Type



SOURCE: U.S. Department of Agriculture, Foreign Agricultural Service, Desk *Reference Guide to U S Agricultural Trade,* Agricultural Handbook *No 683,* revised April 1994

and processed food products, especially the increase in meat exports, involved the use of bulk commodities (feed for cattle, for example). But that increase was not nearly large enough to offset the loss of U.S. bulk commodity exports. As U.S. crop production continued to rise during the 1980s and bulk commodity exports declined (figure 2-8), commodity prices received by farmers fell, decreasing farm income and expanding acreage diversion programs.

In an attempt to discourage further stockpile growth, the United States implemented a Payment-in-Kind (PIK) program in 1983 to reduce crop acreage, using excess stocks to pay farmers to lower production. That reduction in crop acreage, coupled with an extremely severe drought in the Midwestern grain belt, cut grain output by nearly 40 percent in 1983. The return of favorable weather in 1984 meant that surpluses built up again, however, and led to the implementation in 1985 of the Export Enhancement Program (EEP). EEP was designed to stem the losses incurred in global markets and used stocks as payments to exporters for meeting foreign competition. Neither PIK nor EEP, or even a weaker dollar and large export subsidies, changed the global trend toward more trade in processed and consumer-oriented food products. By 1993, global trade in these types of products was up $45 billion over 1980. U.S. exports of these items also increased, rising by $10.0 billion between 1980 and 1993 (23).

Bulk Commodity Trade

Although value-added food trade has risen sharply since 1985, trade in bulk commodities has, as noted above, weakened. Global trade in bulk commodities totaled $87.5 billion in 1980 and fell to $71.6 billion in 1990 (23). While traders and others remained optimistic about long-term prospects, the decline in bulk commodity trade continued, falling to $60.2 billion in 1993. Meanwhile, trade in processed and consumer-oriented food products rose from $89.5 billion in 1980 to $133.2 billion in 1990. With economic recovery under way, global trade in processed and retail food products reached $148 billion in 1993.

The new trends in global food trade should have been familiar to the U.S. food industry, be-

TABLE 2-9: Value of U.S. Agricultural Exports, by Commodity Groups, Fiscal Years 1950-1992

(million dollars)

Fiscal year	Grains & products	Oilseeds and products	Animals products	Fruits, nuts and products	Vegetables and products	Cotton and tobacco
1950	**1,268**	**212**	**301**	**123**	**103**	**1,214**
1955	**1,178**	**410**	**405**	**230**	**143**	**761**
1960	**1,802**	**628**	**429**	**270**	**172**	**1,287**
1965	2,441	1,094	527	323	213	982
1970	2,464	1,676	765	401	500	914
1975	11,230	4,852	1,704	805	1,049	1,938
1980	18,261	9,811	3,757	2,087	2,170	4,382
1985	13,285	6,195	4,075	1,886	2,204	3,555
1990	15,672	6,125	6,610	3,116	4,617	4,079
1992	13,858	7,156	7,756	3,940	5,944	3,763
1993	14,104	7,210	7,781	3,831	6,695	2,969

SOURCE U S Department of Agriculture, *Agricultural Statistics,* U.S. Government Printing Office, Washington, DC, 1981, p 564-565 and 1993, p 474-475, U S Department of Agriculture, Economic Research Service, *Foreign Agricultural Trade of the United States* (FATUS), April 1994

cause they mirrored earlier patterns in U.S. food expenditures. In the 1950s and 1960s, U.S. families began purchasing more and more ready-to-eat food products, cutting back on purchases of flour, potatoes, and other ingredients for homemade food. Two-income families could, and did, spend even more on ready-to-eat food items. The same economic trends led to more food consumption outside the home, in restaurants and fast-food establishments. These same trends are reflected in world food trade: trade in processed and consumer-oriented food products has increased, and bulk commodity shipments have declined. One result is more jobs in food- processing industries, just as more food consumption outside the home led to more jobs in restaurants and fast-food establishments.

Global trade in bulk commodities obviously will not disappear, any more than domestic use of bulk commodities disappeared. The issue instead is one of growth, and adapting to new trends in global markets. Adapting is difficult for the United States, for various reasons. Bulk commodities were at the heart of the U.S. agricultural export boom of the 1970s, and the value of grain exports more than quintupled over the decade (table 2-9). Exports of oilseed crops and products also rose. But as global markets for bulk commodities shrank in the 1980s, U.S. exports of grain and oilseeds declined as well. Other items became the driving force behind export expansion, even as traditional farm programs continued to encourage production of bulk commodities. Animal product exports doubled between 1980 and 1993. Similarly, exports of fruits and nuts nearly doubled, and exports of vegetables more than tripled.

The impact of the shift away from bulk commodities was dramatic. By 1993, bulk commodities made up 44 percent of the value of U.S. agricultural exports, compared with 70 percent in 1980; intermediate products such as soybean meal made up 20 percent, compared with 17 percent in 1980; and consumer-oriented products accounted for 36 percent, compared with 13 percent a decade earlier (23). In little more than a decade, consumer-oriented products had more than doubled their share of U.S. agricultural exports, rising from 13 to 36 percent. On a global scale, consumer-oriented food products had gone from 29 to 46 percent. In 1993, the United States was about where world markets were in 1983, relative to consumer-oriented exports. To catch up and remain the world leader in food and agricultural trade, the United States may need to rethink its farm programs and its export expansion programs. Otherwise, it will likely remain behind the times in global food markets.

Global Marketing Shifts

One geographical area that has been central to the growth of consumer food exports is the Pacific Rim. Japan and Taiwan, along with Hong Kong and Korea, are among the top 10 markets for consumer-oriented food exports—and exports to these countries are growing rapidly. Red meat exports to Japan increased 83 percent between 1988 and 1993. Poultry exports to Hong Kong more than tripled. Exports of fresh tree fruits to Taiwan more than doubled, and exports of these items to Malaysia increased by 50 percent (26).

As development has proceeded, Asian countries have become more prominent players in the international trade arena. Asia replaced Europe as the leading regional market for U.S. farm products as early as 1979 (23). One-third of all agricultural exports went to Asia at that time. The Asian share has continued to increase and reached 37 percent in 1993. In describing the evolution of this trade, a 1994 USDA report noted that:

> Asians have begun to incorporate more Western-style food into their diets. This, in turn, has led to a surge in demand for Western-style consumer-ready goods in Asia. Increases in demand have been most marked for beef, horticultural products, beverages, and pre-packaged foods. Both U.S. beef and poultry meat exports to Asia posted record levels in fiscal 1993. Fueled by a burgeoning demand for a diversity of tastes, U.S. sales of snack food, dairy products, fresh vegetables, and tree nuts to Asia also reached all-time highs (23).

Asian nations are not the only ones increasing imports of food items. Canadian importers are exploiting new opportunities under the U.S.-Canada Free Trade Agreement (FTA) and importing large amounts of food products, a phenomenon that has made Canada the world's largest importer of U.S. food products. Mexico is also increasing food product imports and ranks third, after second-place Japan, as an importer of U.S. food products. Other countries in the top 10 include Hong Kong, Germany, the United Kingdom, South Korea, Taiwan, France, and the Netherlands.

The expansion of trade in food products has had a positive effect on the nation's trade balance. Some of the processed items shipped, however, are tradeoffs for bulk commodities. Exports of corn and red meat to Japan provide a good illustration. Total shipments of red meat to Japan increased steadily and reached $3.1 billion in 1993, a full 83 percent above the value of red-meat shipments made in 1988 (26). Japanese corn imports totaled 16 million metric tons in 1993, the same amount as five years earlier (25). The Japanese case is not unique. According to the February 1994 issue of the USDA's FAS grain circular (24):

> After expanding at about 5 percent annually throughout the 1960s and 1970s, the growth rate for corn utilization outside the U.S. fell dramatically in the 1980s. If China and other major corn exporting countries are excluded, corn utilization in the remaining countries only increased a net 6.7 mmt [million metric tons] from marketing year 1980/81 to 1993/94, a rate of about 0.2 percent annually. Over the same period, U.S. corn utilization expanded 37.7 mmt, a rate of about 2.3 percent annually.

Slow growth rates were not alone in hurting bulk commodity exports. Another USDA grain circular (25) noted that Latin America is importing more wheat and now accounts for 15 percent of world trade in wheat, but that "U.S. wheat has become relatively uncompetitive." In this instance, both the European Union (EU) and Argentina have successfully replaced the United States as a supplier of wheat to Latin America.

Although drought or some other unforeseen event could lead to rapid growth in bulk commodities almost overnight, as the 1970s demonstrated, the availability of supplies from other exporting countries suggests that the likelihood of permanent increases is low. Planning public policy around such an expectation does not appear to be very realistic.

Alternatively, the probability of further growth in consumer food exports appears higher, and planning public policy to take advantage of that growth seems more promising. What is evident on the basis of past trends is that some change in policy is needed. The United States had a 23 percent share of global food and agricultural trade from 1980 to 1984, but only 20 percent in 1992. Over the same period, the EU took advantage of the shift toward processed food products and increased its share of world food trade from 14 percent in the years 1980 to 1984, to 19 percent in 1992 (23). Even though the United States has increased its consumer food exports, world markets have grown even faster. The ultimate outcome: other countries have absorbed a more-than-proportional share of world food markets, and the United States has been losing out.

THE U.S. DILEMMA

Part of the U.S. dilemma with regard to agricultural exports has been the aforementioned slow growth in world markets for bulk commodities, as well as fierce competition from the EU and other food-exporting countries. But part of the reason for the declining market share may be ascribed to the United States' overemphasis on bulk commodities. Price supports and deficiency payments for wheat, rice, cotton, and feed grains prevent the United States from taking maximum advantage of opportunities to export intermediate products such as soybean meal and wheat flour. While global trade in semiprocessed products increased by $13.5 billion between 1980 and 1993, U.S. exports of oilseed products dropped, from $9.8 billion to $8.3 billion (13,15). U.S. soybean acreage also declined, from 68 million acres harvested in 1980 to 57 million acres in 1993 (13,15). Despite changes in the 1990 farm bill designed to free up more program acres for soybean production, soy bean plantings continued to lag. Apparently, support payments for planting other crops are more important than planting more soybeans, no matter how many acres are available for doing so.

Like global trade in intermediate agricultural products, global trade in consumer-oriented food products also rose dramatically between 1980 and 1993, by $45 billion. U.S. exports of these items increased, by $10 billion—but mostly in response to the efforts of private firms. Government promotion programs continued to focus on exporting excess supplies of wheat, feed grains, and other price-supported bulk commodities. With budgets already limited, there were few funds left over to promote exports of processed and retail-ready food items. Farm legislation may also act as a constraint. Examples include the legislative prohibition on planting of fruits and vegetable crops on flex acres and the administrative regulation against grazing and haying of CRP acres. Both prevent more production of items that are in growing demand in global markets.

RESEARCH AND DEVELOPMENT

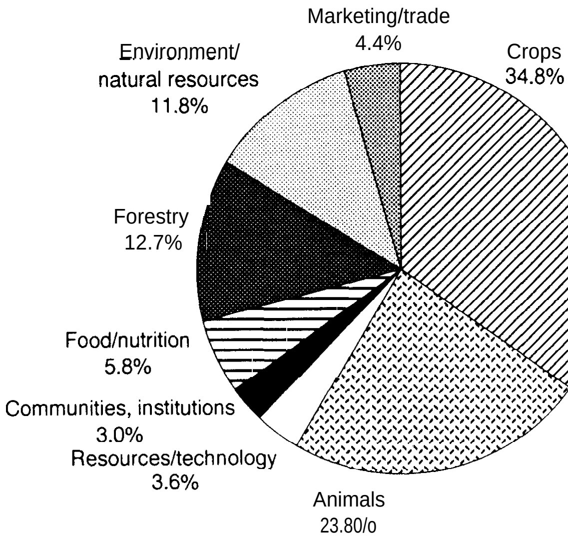
The task of providing information to the public on trends in international agricultural trade falls to government agencies and the agricultural research community. The challenges vary from reporting events in individual countries that will shape trade in the coming year to assessing trade agreements that will influence the patterns of food exports and imports for coming decades. On the commercial side, the task includes monitoring trends in food consumption, along with changes in government regulations, to anticipate new marketing opportunities. On the economic front, the task includes following trends in earnings and assessing where trade patterns are likely to change.

Achievements in these research areas contrasts sharply with achievements in research on food production. On the technological side of agriculture, the nation has benefited from a long stream of scientific breakthroughs that raised agricultural output and lowered the real cost of food and fiber. Although such technological breakthroughs were newsworthy achievements in earlier decades, most are greeted today with little fanfare. Their lack of visibility does not, however, mean that they are unimportant, or that food costs are absorbing a larger share of national income. In as recent a period as 1983 to 1992, the percent of disposable personal income spent on food in the United States declined on average from 13.0 percent to 10.6 percent—a truly remarkable achievement, considering that food purchases consist more of processed and ready-to eat items than they have before (15).

One explanation for the different level of research achievements can be found in the budgetary resources devoted to food production and agricultural trade. In 1993, the nation devoted $3.0 billion to agricultural research through federal and state research institutions (16). As shown in figure 2-9, the allocation of these funds heavily favored crop and livestock production. Research on crops received 34.8 percent of the total funds, while research on animals received 23.8 percent. Both far outdistanced funding on international and domestic markets, which accounted for 4.8 percent of total research funds. Research expenditures on people and institutions accounted for even less: 3.0 percent of the total, or $88,353,000 of federal funds. With the Uruguay Round Agreement (URA) implemented this year, and the new World Trade Organization (WTO) in place, opportunities for expanded trade (and the adjustments to the agriculture sector they may bring) may justify more investment in examining changing international markets and their impact on U.S. agriculture.

Food consumption trends in other countries differ from trends in the United States. As a mature industrial nation with a population structure to match, U.S. food demand is relatively stable. Many of the countries that will be responsible for shaping the composition of future global trade in food products, however, are at a different stage of development, with different income levels and different responses to changes in incomes, food prices, and availability of new food products. For the United States to become proficient at marketing food in these countries, it must become more knowledgeable about their internal conditions, about food tastes and taboos, and about cultural habits that shape food consumption. In essence, the United States must learn more about the differences among countries and shape marketing programs to match other countries' needs rather than our own. This will be a major challenge for the research community, as well as the business community, in coming years.

FIGURE 2-9: Agricultural Research Funding 1993



Total funding $2,970,911,000

SOURCE: U.S. Department of Agriculture, Cooperative States Research Service, Inventory of Agricultural Research, Fiscal Year 1993 Washington, DC, 1993.

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Global Markets and International Trade Agreements 3

Since the 1970s, U.S. exports of goods and services have grown rapidly. Agriculture and industry alike have turned to international markets as a place to sell their excess production, bolster employment, and enhance revenues. Yet the United States' fortunes in international food markets have fluctuated considerably. The booming markets for commodities (e.g., wheat, corn, and other grains) of the 1970s gave way to declining shipments in the early 1980s; the mild recovery of the late 1980s was succeeded by relative stagnation in the early 1990s. Over the past two and a half decades, the United States has lost its commanding share of world commodity trade.

Although exports of value-added food products (e.g., fruits, vegetables, and meats) continue to grow, the future for commodity exports is uncertain. Future shipments of bulk commodities depend on a number of factors not directly affected by U.S. policy: weather at home and abroad, foreign economic prospects, global population growth, and the introduction and application of new agricultural technologies in other countries. But future shipments also depend on factors directly related to U.S. policy: the shape of government programs to come, how those programs mesh with trends in growing global markets; and the impact of international trade pacts such as the Uruguay Round Agreements (URA) and the North American Free Trade Agreement (NAFTA).

This chapter examines the possible effects of these factors on U.S. prowess in world food markets. Generally, it appears that government policies appropriate in the 1960s and earlier are far less appropriate for the 1990s and the 21st century. Agricultural markets have changed, much as the structure of American agriculture has changed, and new growth opportunities differ from those of the past. The 1960s emphasis on bulk-commodity ex-

ports, for example, has persisted into the 1990s, at a time when high-value products, and particularly consumer-oriented food products (e.g., ready-to-eat foods), comprise a growing share of global trade and of U.S. exports.

Currently, neither domestic export programs nor international trade agreements have helped U.S. farmers to synchronize U.S. production and exports with trends in global markets. The URA provisions may nudge U.S. farmers toward exporting more high-value products, but domestic farm and export programs will discourage them from doing so. Clearly, one of the major challenges ahead is to reshape these programs, and the incentives they provide, so that U.S. farmers are growing the kinds of products demanded by international markets. An obvious example of the need for such reshaping can be found in the oilseed market. Even though global demand for soybeans has grown, U.S. farm programs led U.S. farmers to plant fewer acres with soybeans, and U.S. exports of the crop stagnated (although this situation was addressed in the 1990 farm bill). Similarly, even though fruits and vegetables are in high demand globally, the use of government flex acres for fruit and vegetable production is limited. Future legislation may need to address the use of flex acres and currently idled acres to encourage more output of fruits, vegetables, soybeans, and other items valuable in the global marketplace.

The United States' approach to international trade agreements also reflects a multiplicity of purpose. Even though it is a strong supporter of international trade negotiations and international trade agreements, the United States continues to implement policies for supporting commodity prices and subsidizing commodity exports that often conflict with the spirit of international trade agreements. For example, the U.S.-Canada Free Trade Agreement (FTA) lowered barriers to trade, including trade in food and agricultural items, between the two countries. U.S. farm programs, however, restrain wheat production and U.S. export subsidies encourage wheat exports. The result: wheat prices in the United States rise, and the price of wheat overseas falls. Because U.S. wheat prices are above world levels, Canada in 1994 shipped more wheat to the United States, which responded by pressuring Canada to restrict its wheat exports.

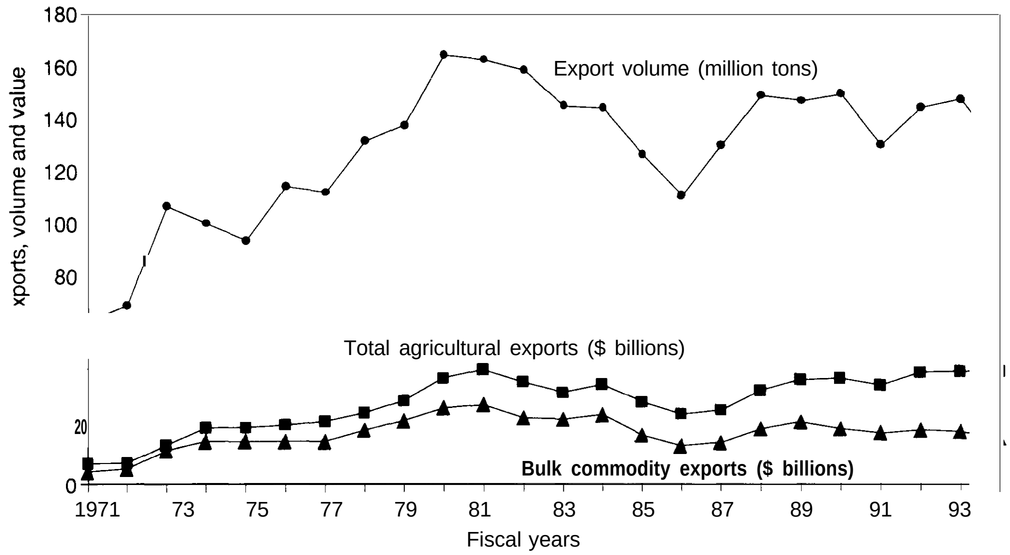
The URA, which went into effect on January 1, 1995, will further reduce trade restrictions. Fewer restrictions on trade may, as illustrated by the U.S.-Canada wheat imbroglio, increase the likelihood of agricultural trade conflicts in the future, given current policies. Thus, the United States finds itself at a crossroads where the dichotomy between its support for global free trade and its policy of insulating agricultural interests from the global marketplace may be too burdensome to sustain. The country is confronting a crucial choice: whether to move toward free agricultural markets and open world trade, or continue subsidized exports and restrictions on agricultural imports. The decision will, to a substantial degree, determine the economic standing of U.S. agriculture in the global economy of the 21st century.

GLOBAL MARKETS AND U.S. PARTICIPATION

World population growth, rapid economic development, and several rounds of international trade negotiations have expanded global trade in food and agricultural items. World shipments of food and agricultural goods totaled $41 billion in 1970, and increased to $208 billion in 1993 (17). Twenty-one percent of the agricultural goods traded came from the United States in 1993, making it the world's largest agricultural exporter—although it was followed closely by the European Union (EU). The impact on the U.S. farm economy was substantial, as export markets absorbed sizable amounts of bulk commodities (e.g., such as wheat, corn, and other grains) and growing amounts of value-added foods (e.g., fruits, vegetables, meats, and processed foods). The shipments raised farm income, lowered farm program costs, and slowed the decline of rural communities.

The growth of U.S. agricultural exports has not followed a steady path. Between 1970 and 1981, the annual value of U.S. agricultural exports soared from $7 billion to $43.8 billion (figure 3-1). Then, a combination of a stronger dollar, a

FIGURE 3-1: U.S. Agricultural Exports 1971-94



SOURCE: U.S. Department of Agriculture, Foreign Agricultural Service, *Desk Reference Guide to U.S. Agricultural Trade,* Agriculture Handbook No 683, revised January 1993

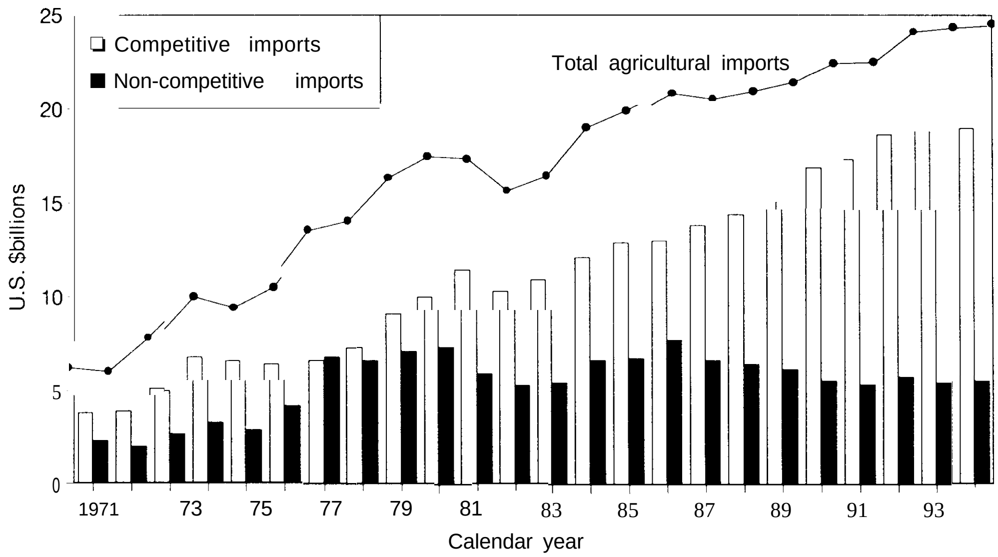
changing global economy, and new farm legislation drove farm exports down to a low of $26.3 billion in 1986 (17). Bulk commodities suffered the most, declining from $30.4 billion in 1981 to $14.2 billion in 1986. New farm legislation, a weaker dollar, and export subsidies reversed the trend after 1986, and farm exports reached $43.1 billion in 1993. Bulk commodity shipments also recovered a portion of their loss, reaching $19.0 billion in 1993.

Three key changes in the global economy precipitated the export decline of the early 1980s. First, the EU made a concerted and highly subsidized push to gain world market share in agricultural products—a move that depressed world prices, limited U.S. agricultural exports, and earned the sobriquet "trade war." Second, new technologies raised grain output in many developing countries. This "Green Revolution" obviated the developing countries' need for substantial grain imports. Third, world food trade shifted toward value-added food products. Nonetheless, the United States remained the world's largest exporter of agricultural goods—although a significant part of the growth was due to increased exports of processed and consumer-ready food products.

Imports of food and agricultural products into the United States have also grown, rising steadily over the past several decades. The types of imports change from time to time, more as the result of domestic political pressures than changes in foreign supplies. Meat imports, for instance, are occasionally restricted by "voluntary restraints" imposed on countries exporting meat to the United States; wheat imports decline in response to threats of Section 22 action;] and size, grade or

[1] Section 22 was part of the Agricultural Act of 1935. It authorized the President to impose restraints on import of farm commodities whenever imports threatened to interfere with the effectiveness of price support programs for commodities covered by the Agricultural Adjustment Act of 1933.

FIGURE 3-2: U.S. Ag



SOURCE U S Department of Agriculture, Foreign Agricultural Service, Desk *Reference Guide, 1994*

other specifications occasionally restrict fruit and vegetable imports. Such actions contrast sharply with an overall U.S. trade policy that favors lower trade barriers, lower export subsidies, and expanded channels of global commerce.

As a food importer, the United States is a significant world player, ranking as the world's fifth-largest behind Germany, Japan, Italy, and the United Kingdom (15). U.S. food imports accounted for about 12 percent of world food trade in 1993, down from the 14 percent of 1971 but up from the 9.5 percent of 1981. Some of the growth in imports comes from items not grown in the United States, but a much larger part consists of items that are also grown domestically. Competitive imports (imports of items also grown here) increased from $1.6 billion in 1950 to $18.9 billion in 1993 (figure 3-2) and now make up 75 percent of all food imports, compared with a 50-percent share in 1950. They include a wide range of items such as meats, vegetables, fruits and nuts, oilseed products, and sugar and sugar products. Noncompetitive or supplementary food imports (imports of items not grown in the United States) increased more modestly, from $1.6 billion in 1950 to $5.5 billion in 1993. Included are items such as bananas, coffee, cocoa, tea, spices, silk, rubber, nursery stock, certain beverages, and processed food products. Together, competitive and supplementary imports helped raise U.S. food and agricultural imports from $3.2 billion in 1950 to $24.4 billion in 1993 (17).

Some of the growth in imports reflects changing U.S. food tastes, as well as immigration and internal population growth. Many immigrants brought deeply ingrained food preferences from their native countries. Most of the increase, however, has stemmed from price inflation, economic growth, and the broadening of food tastes that comes with higher incomes.

A final factor has been lower trade barriers. The rounds of international trade negotiations completed since the GATT was established in 1947 (box 3-1) have lowered U.S. tariffs and other border restrictions. Although agricultural trade barriers--especially nontariff barriers that protect internal support programs for farmers-were largely left out of the early rounds of trade negoti-

BOX 3-1: International Trade Negotiations of the General Agreement on Tariffs and Trade

Geneva, Switzerland	1947	First round 22 countries participated
Annecy, France	1949	Second round 32 countries participated
Torquay, England	1950-51	Third round 33 countries participated (Germany joined GATT)
Geneva, Switzerland	1956, . .	Fourth round 34 countries participated (Japan joined GATT)
Geneva, Switzerland	1961-62,	Dillion Round 37 countries participated
Geneva, Switzerland	1963 -67.....	Kennedy Round 62 countries participated
Tokyo, Japan	1972 -79...	Tokyo Round 102 countries participated
Punta del Este, Uruguay	1986 -93..	Uruguay Round 117 countries participated

SOURCE Office of Technology Assessment, 1995

ations, lower tariffs on food items from these rounds brought about a steady increase in world food trade and a steady rise in U.S. food imports. With increased food trade came a globalization of food tastes: Americans ate more European cheeses, and Europeans ate more American chicken, pork, and beef. Even though Europe and the United States carefully protected their farm sectors from import competition (which increased the overall difficulty of negotiating lower trade barriers), some trade barriers to food products were eased. Trade between the United States and Europe continued to increase.

Trade also expanded between the United States and Asian countries, although the composition of that trade was different. Exports from the Pacific Rim countries were largely industrial products; Pacific Rim imports were more heavily oriented toward raw materials and bulk commodities. Japan, for example, imported large quantities of raw materials from the United States and exported large amounts of finished goods (which helps explain the large trade differential between the two countries). In 1993, the trade U.S./Japanese differential amounted to $60.5 billion, or 46 percent of the total U.S. trade deficit (2).

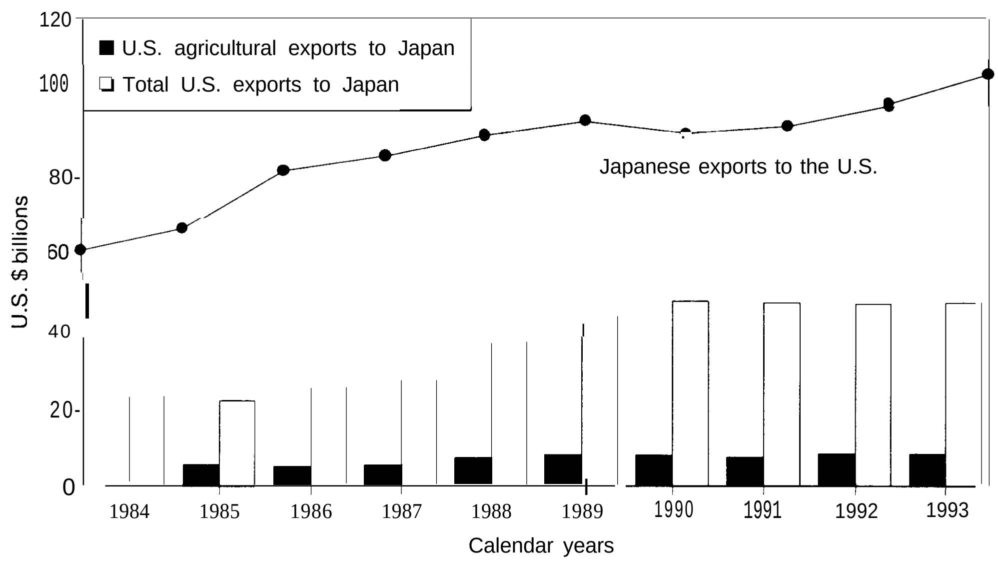
Exports to Japan from the United States totaled $46.7 billion in 1993, while imports from Japan amounted to $107.2 billion. Of the $46.7 billion in goods that Japan imported from the United States in 1993, $8.4 billion consisted of agricultural goods (figure 3-3). Although these figures made Japan the world's largest single market for U.S. agricultural goods, such shipments offset only a small portion of the $60.5 billion Japanese trade surplus. Figure 3-3 also illustrates that despite years of negotiations over market access for such products as beef and citrus fruits, U.S. agricultural exports to Japan have increased only modestly.

INTERNATIONAL TRADE POLICY AND U.S. AGRICULTURE

The gradual easing of import restrictions on food and agricultural products is a post-World War H phenomenon. Before the war—more explicitly, during the Great Depression—the United States had established an extensive framework of import restrictions designed to protect its farmers from import competition. That restrictive framework was part of an extended history of promoting agricultural exports abroad and protecting agricultural interests at home.

As early as 1789, the first Congress of the United States—in only its second legislative act—levied tariffs on imported goods. The move was not aimed solely at protecting domestic industries from foreign competition. Rather, it was chiefly designed to raise revenue. From 1789 until the introduction of an income tax in 1913, tariffs and land sales were the main sources of revenue for the federal government. However, as incomes taxes provided the government with operating funds, and as industrial development made U.S. industries less dependent on tariffs or other forms of economic protection, the focus of U.S. trade policy moved away from tariffs and toward eco-

FIGURE 3-3: U.S. and Japan Trade



SOURCES: Executive Office of the President, Council of Economic Advisors, *Economic Report of the President* (Washington, DC: U.S. Government Printing Office, 1995), U S Department of Agriculture, Foreign Agricultural Service, *Desk Reference Guide to U.S. Agricultural Trade,* Agriculture Handbook No 683, revised January 1990

nomic development. In 1916, Congress passed the Underwood-Simmons Tariff Act, which specified that the President could lower many tariffs, and that some items could be made duty free. When the United States entered into World War I in 1917, tariffs became a moot issue, as the overseas war effort required large exports of U.S. products.

The evolution of an agricultural trade policy independent of the nation's generally open trade policy began after World War I. Farmers had been encouraged by the federal government to expand their production capacity to meet the war needs. When the war ended abruptly in 1918, they were confronted with shrinking markets and falling prices. Responding to demands for relief, Congress enacted the Emergency Tariff Act of 1921, which imposed heavy duties on imported agricultural goods. However, the action had little effect on farm prices, which continued to be depressed by the excessive supplies burdening commodity markets. To make matters worse for farmers, in 1922 Congress passed the Fordney-McCumber Act. This legislation gave the President the power to raise tariffs on items farmers purchased—a power that the President exercised 32 times during the next decade, mostly to raise industrial tariffs.

As industrial tariffs rose, farmers charged they were being treated unfairly because they were forced to buy inputs on a highly protected domestic market, while selling products on open markets abroad. The debate went on for a decade. Twice Congress passed legislation to rectify the apparent inequity; twice Presidents vetoed it. As rural economic conditions continued to deteriorate, Congress produced legislation establishing a Farm Board to ensure orderly marketing of farm commodities (1929); voted in the Smoot-Hawley Tariff Act, which raised tariffs to record highs (1930); and approved an Agricultural Adjustment Act (1933) that established stable domestic prices for agricultural goods aimed at "parity" with other sectors of the economy. The Farm Board proved unworkable, the Smoot-Hawley Tariff Act a disaster, and the AAA in need of amendment.

Throughout the history of the nation, Presidents have been responsible for initiating changes in trade policy.

. . . and the Congress has been responsible for determining the final direction and magnitude of change in the nation's trade policy.

The AAA was amended to address trade problems in 1935. Section 22 authorized quantitative limits on imports of certain commodities, such as wheat, cotton, and some sugar, so that domestic price support programs for these commodities would not be hampered.[2] Section 32, in contrast, was an initial move toward establishing export subsidies. The new section provided funds (30 percent of all revenues earned from tariffs and duties) for financing programs to dispose of surplus agricultural commodities. In the initial years, the disposal efforts focused on giving surplus items to domestic groups, such as schools and churches, although some funds were spent to subsidize specific commodity exports. Neither was very successful in solving surplus production problems. Only the outbreak of World War II brought the magnitude of demand needed to balance out excess agricultural supply.

EVOLUTION OF EXPORT PROMOTION PROGRAMS

Farm exports boomed with the outbreak of World War II, and the farm economy remained strong for most of the next decade. With the end of the Korean War in 1953, however, U.S. farm exports fell precipitously and agricultural surpluses grew. In 1954, Congress passed the Agricultural Trade Development and Assistance Act (Public Law 480) to boost farm exports. The act, which came to be commonly known as the Food for Peace program, offered food assistance to needy nations and also provided the basis for U.S. overseas market development programs.

[2] Numerous amendments were made to Section 22. The first came on February 29, 1936 (c. 104, Sect. 5,49 Stat. 1152); the rest on June 3, 1937 (c. 296, Sect. 1, 50 Stat. 246); January 25, 1940 (c. 13, 54 Stat. 17); July 3, 1948 (c. 827, Title I, Sect. 3, Stat. 1248); June 28, 1950 (c. 381, Sect. 3, Stat. 261); June 16,1951 (c. 141, Sect. 8(b), 65 Stat. 75); August 7,1953 (c. 348, Title I, Sect. 104,67 Stat. 472); and January 3,1975 (Pub. L 93-618, Title I, Sect. 171,88 Stat. 2009). In more recent years, Section 22 has become less important, as lower price supports have reduced the incentives for other countries to export price-supported items to the United States.

The Foreign Market Development Program (FMDP)—a term that covered all of the new promotion programs authorized by P.L. 83-480—drew together the U.S. Department of Agriculture (USDA) and private U.S. interest groups to promote overseas sales of U.S. agricultural products. The programs under FMDP used a variety of means to aid exports, which included developing livestock production in other countries to promote exports of U.S. feedstuffs, as well as food store displays in other countries to introduce foreign consumers to retail products made with U.S. food grains. These so-called cooperator programs slowly built markets abroad. The food aid programs similarly introduced a wide range of food commodities to foreign consumers. All of the programs focus on building long-term demand and consequently operated even during the export boom years of the 1970s.

Today, the cooperator programs operate with an annual budget of roughly $37 million (4). Under P.L. 480, the United States annually exports about $1.5 billion in food and agricultural items, or more than $15 billion in agricultural goods since 1980 (17). Donations under Section 416 of the Agricultural Act of 1949 (as amended in 1985) continue to provide surplus commodities held in Commodity Credit Corp. (CCC) inventories.[3] Outlays for Section 416 totaled $2.2 billion between 1983 and 1993. These programs were expanded during the 1980s, as commercial sales slumped.

Other programs to assist U.S. agriculture were established during the slump of the 1980s, including such CCC mechanisms as the Export Guarantee Program (GSM-102, which provides six-month to three-year credit for foreign purchasers of U.S. agricultural goods) and the Intermediate Export Credit Guarantee Program (GSM-103, which provides three-year to 10-year credit for foreign purchasers). Both programs assure U.S. banks that loans to foreign buyers who default will be repaid by the U.S. government. GSM-102, the major credit guarantee program inaugurated in September 1980, has assisted in the export of $35 billion in agricultural commodities, including $7 billion that also received subsidies under the Export Enhancement Program (EEP). As reauthorized by the Food Security Act of 1985, the Export Enhancement Program "sweetens" trade deals by giving exporters bonus certificates that may be redeemed for commodities owned by the CCC. Since its inception in 1985, EEP has distributed more than $6.2 billion in bonuses, leading to shipments of 143 million tons of wheat, 6.2 million tons of wheat flour, 13.2 million tons of barley, 917,000 tons of rice, and a variety of other agricultural exports (17).

The Food, Agriculture, Conservation, and Trade Act of 1990 produced the Market Promotion Program (MPP) as a replacement for the Targeted Export Assistance (TEA) program that operated from 1986 to 1990. Both programs were intended to boost exports of specialty crops, processed commodities, and consumer food items. The MPP was authorized to operate for fiscal years 1991 through 1995 to help U.S. producers and other groups to promote exports of U.S. agricultural products by assisting exporters with cash or CCC generic commodity certificates.[4] According to USDA, an MPP annual authorization of $200 million was expected to lead to an annual increase of between $400 million and $1.4 billion of agricultural exports (16). From 1990 through 1993, when appropriations approximated $200 million, exports of intermediate (semiprocessed) commodities rose an average of $166 million annually. Exports of consumer-oriented food items rose an average of $1.5 billion annually between 1990 and 1993.

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[3] CCC is USDA's financing institution for its price support and export operations. It can draw up to $25 billion for the U.S. Treasury.

[4] Generic certificates are paper statements issued by USDA that authorize the holder to receive commodities owned by the CCC equal in value to the amount specified in the certificate. As its name suggests, the generic certificate may be redeemed for any commodities owned and available from the CCC.

TABLE 3-1: Export Enhancement Program Bonuses for Wheat, 1985-1994

Fiscal year	EEP total $1,000s	Wheat EEP total $1,000s	Percent wheat
1985	22,477	10,920	48.6
1986	256,250	126,922	49,5
1987	927,759	541,601	58.4
1988	1,013,655	819,534	808
1989	338,765	288,929	853
1990	311,751	241,882	77,6
1991	916,599	767,702	83.8
1992	968,199	813,205	840
1993	967,278	774,826	80.1
1994 (until 3-17-94)	597,678	452,888	758
Total	6,320,411	4,838,410	766

SOURCE: U.S. Congress, General Accounting Office, *Wheat Support The Impact of Target Prices Versus Export Subsidies,* GAO/RCED-94-79 (Washington, DC, June 1994), p 48-49

IMPACT OF EXPORT PROMOTION PROGRAMS

Twenty-one percent of all agricultural exports in FY 1993 were assisted by one kind of government program or another (16). But has this panoply of promotion programs, which together account for more than 70 percent of all U.S. funds spent on export promotion (l), been a marked success? The answer is both yes and no. Examined from the perspective of the commodities supported, the programs have had a positive influence on export levels. Confirmation comes in various forms, including the strong support these programs receive from the commodity interest groups involved and the large amount of criticism leveled against them by competitors abroad. Much of that criticism focuses on the price-depressing effects of export subsidies, which lower the returns for their nonsubsidized commodity exports.

If the assessment is broadened beyond the specific commodities involved and takes into account world markets that are moving toward processed and consumer-ready food items, as discussed in chapter 2, the benefits of the current programs are less clear. The rapid growth of processed food trade globally and the weaker markets for bulk commodities have changed overseas marketing opportunities. With the notable exception of the MPP, which is geared toward promoting fruits, vegetables, poultry, wine, and wood products, the U.S. government makes few efforts to promote consumer-oriented food items. The cooperator programs, for example, have traditionally spent far more on grain, feed, and oilseed exports than on such consumer-oriented products as fruits, vegetables, and meats (l). Likewise, most EEP funds have been directed toward subsidizing exports of wheat, in an effort to stave off EU dominance in the global wheat market (table 3- 1). EEP support can be and has been criticized because the subsidized sales may have taken place anyway, and instead of reducing overall EU sales, EEP's effect may simply have been to divert those sales to other countries. This in turn could have reduced U.S. market share in those countries. With the MPP, the major question is whether, if the program did not exist, private interest groups would have spent the same amount of money on market promotion. There appears to be little argument with MPP's focus on higher valued products.

By contrast, EEP's heavy focus on bulk commodities can be criticized for other reasons. Before the world food shortages of the 1970s, many importing nations had little appreciation for the benefits of grain stockpiles, but their outlook is different today. The effect is clear in stagnating global trade in bulk commodities, and in stable levels of bulk commodity exports from the United States. Although bulk commodity exports may increase in the future, such increases will likely be due to ephemeral phenomena (bad weather, for example) or heavy export subsidies (which raises questions about the net benefit gained). From the nation's standpoint, a more effective policy would be to take advantage of markets that are growing rapidly, such as those for vegetables and meat, and reduce emphasis on markets that are stagnant, such as those for wheat and other bulk commodities.

A second problem with current export promotion programs is their lack of cogency. Even if the MMP is a step in the right direction, for example, it has been criticized as suffering from a vagueness of purpose and direction, which renders it less efficient and effective than it should be. Critics contend that other programs suffer from a similar malaise. Abel, Daft and Early conclude that:

> USDA's allocations of market development funds [for the FMDP and MPP] have sometimes taken place without sufficient regard to maximizing the effectiveness of these expenditures with respect to either expanding exports or benefiting agricultural producers. Neither Congress nor USDA has provided a clear and defensible set of criteria that define the intended universe of market development activities to be covered by both the FMDP and MPP (1).

There have been many suggestions for improvement. Some contend that the FMDP and the MPP need more specific guidelines for which products to promote, that the programs' objectives should be more clearly defined, and that export performance and future prospects should be evaluated market by market (1).

A final problem associated with government programs is that they simply cost too much. To maintain export shipments of bulk commodities in the face of shrinking global markets, more and more programs have had to be added, with higher costs. Early on, programs such as Section 416 and Titles II and III of P.L. 480 provided food aid at little or no cost to foreign recipients. As foreign competitors complained and U.S. costs for cargo preference rose,[5] the United States substituted export credit guarantees for food aid. Export loans were extended to any market in which there was a reasonable prospect of repayment, a step that has come under considerable criticism.[6] When loans and food aid were no longer effective, given changing global food trends, the United States added direct export subsidies through EEP. At each step, costs increased. Bulk shipments, however, flattened out after initially responding to EEP subsidies, in contrast to a continuing growth in shipments of value added food items. (See figure 3-1.)

Although experts disagree about the future of bulk commodity exports, there seems to be more of a consensus that growth in processed and consumer-ready food exports will continue, barring a major downturn in the world economy. This prognosis leaves the United States with hard choices regarding the ideal level of land retirement programs; the optimum amount of crop output; the appropriate level of export promotion outlays for bulk and processed commodities; and the amount of outlays for research on traditional and industrial crops, as well as for improved understanding of global markets. Because these choices each involve trying to anticipate future trends in global agricultural production and demand, none of them is clear cut. It is also important to keep in mind the state of domestic food balances, even though food surpluses have been a far larger problem than food scarcity in the United States over recent decades.

INTERNATIONAL TRADE AGREEMENTS

The United States pursues its agricultural trade goals not only through domestically based export promotion programs and trade restrictions, but also through a variety of international trade agree-

[5] Federal law requires that a specified proportion of food aid be shipped on American cargo ships, which have substantially higher costs per ton of cargo shipped. The costs of shipping food aid rose as the so-called cargo preference law was implemented.

[6] GAO estimated that about $6.5 billion of the $13.55 billion in outstanding loan guarantees would not have been repaid if the programs had ended on June 30, 1992 (9). Substantial losses were incurred when Iraq defaulted, following the Gulf War in 1990. After the breakup of the Soviet Union, Russian defaults were prevented only through debt rescheduling by the so-called Paris Club.

ments. A decade of negotiation was required, but today the United States is party to the U.S.-Israel Free Trade Agreement, the U.S.-Canada Free Trade Agreement (FTA), and the North American Free Trade Agreement (NAFTA) with Canada and Mexico. It is also a founding member and major sponsor of the General Agreement on Tariffs and Trade (GATT), which dates back to 1947 and was succeeded this year by the World Trade Organization (WTO).

Since its inception, GATT and more recently, the WTO has been the chief mechanism through which the United States has pursued international trade negotiations and the goal of trade liberalization. Eight rounds of multilateral negotiations to lower tariffs have taken place. Each of these rounds significantly reduced tariffs on industrial products, but had much less of an impact on agricultural trade—partly because agriculture trade is affected less by tariffs than by nontariff barriers (NTBs) such as import quotas, border fees, variable levies, and import licenses. Although these barriers have generally been inconsistent with GATT rules, GATT members, over the decades, have become quite adept at acquiring exceptions or waivers that suit their needs.[7]

The United States, for example, secured a GATT waiver for its dairy price support programs in 1951.[8] In 1955, it received another waiver for Section 22 quotas on sugar.[9] The United States also encouraged special GATT treatment for agriculture when it set up programs to aid exports of agricultural products, including direct export subsidy programs and food aid programs. Both were prohibited for industrial products under GATT rules. As other countries began to implement export subsidies, the United States pushed for and won agreement in the Tokyo Round for limits on export subsidies for agriculture. The provision—that subsidies are acceptable only as long as a country does not take more than an equitable share of the world market—limited but did not prohibit countries from operating agricultural export subsidy programs.[10]

The exceptions granted the United States have not been unique. The EU, for example, used similar exemptions to operate the Common Agricultural Policy (CAP) it established in 1961. Such moves to protect domestic agriculture under GATT have been considerably at odds with decades of GATT efforts to liberalize trade, most of which had little effect on agriculture. The Kennedy Round negotiations (1965-1967), for instance, were not markedly successful in reducing barriers to agricultural trade. After extended efforts to break an impasse between the United States and the EU (then the European Community, or EC), the agricultural discussions ended up focusing on a further reduction of tariffs and a World Grains Arrangement that, concluded under the auspices of the International Wheat Council, ultimately did not work. The Tokyo Round (1974-1979) also

[7] Article XI of the General Agreement prohibits the use of quantitative import and export restrictions. There are three exceptions that relate to agriculture: (a) temporary export restrictions may be applied to prevent or relieve shortages of food or other essential products; (b) import restrictions may be used for any agricultural or fisheries product where such restrictions are necessary to enforce domestic marketing or production restriction programs or for the removal of temporary surpluses; and (c) both import and export restrictions may be used if necessary for establishing standards for classification, grading, or marketing of commodities (11).

[8] When imports of dairy products threatened to interfere with the price support program in 1951, Congress amended Section 22 of the Agricultural Act of 1935, making mandatory the imposition of import quotas or fees whenever imports threatened to render ineffective any domestic price support program—even if the quotas or fees were inconsistent with the obligations of the United States under previous trade agreements. The 1951 amendment to Section 22 stated that "[n]o trade agreement or other international agreement heretofore or hereafter entered into by the United States shall be applied in a manner inconsistent with the requirement of this section." 7 U.S.C. 624(f).

[9] In addition to Section 22 import restrictions, import quotas on sugar are imposed using authority under Headnote 2 of Part 10A of Schedule 1 of the U.S. Tariff Schedule (TSUS). The United States also has a GATT waiver for this headnote authority. For a discussion of other import restrictions used by the United States, see (11).

[10] An "equitable share" was defined in the Subsidies Code negotiated in the Tokyo Round as "the average share in three recent, representative years" (11).

brought little progress, even though agriculture was identified as a separate agenda item in the Tokyo Declaration.[11] In the end, the United States provided additional access for cheese and other livestock products, Japan expanded its quotas for beef and citrus imports, and the EU reduced its tariffs on tobacco, beef, and poultry.

Unsurprisingly, agriculture proved a major stumbling block in the recent Uruguay Round (1986-1993). Throughout the early years of the Uruguay Round negotiations, the United States pushed for the complete elimination of all subsidies and restrictions on agricultural trade, while the EU argued for a slow phase-out of agricultural subsidies. Early in 1989, after the inauguration of a new U.S. President, and the appointment of a new cabinet and a new U.S. trade negotiator, the United States eased its hardline position on agriculture, while the EU, responding to budget pressures from higher agricultural spending, eased its opposition to reduced support levels. Eventually, after negotiations had broken down several times over the extent to which support levels should be reduced, an "historic" agreement was reached in December 1993. After extensive review, legislation was introduced into both houses of Congress to approve the Uruguay Round Agreements (URA). On December 1, 1994, the Senate followed the House of Representatives in passing the legislation by a wide margin of votes. After seven years of negotiations and six months of consideration by the Congress, the URA went into effect on January 1, 1995. Its agricultural provisions are summarized in box 3-2.

TERMS OF THE NEW TRADE AGREEMENTS

The new bilateral and multilateral agreements for managing international trade are more inclusive than past agreements. Among the new issues that have been recognized and addressed for the first time is the impact of trade on the environment. In a multilateral context, trade and environmental issues will be addressed by a new WTO Committee on Trade and the Environment, which has been commissioned "to immediately prepare for the WTO's work in this area by examining:

- the transparency of the present international system;
- exports of domestically prohibited goods;
- the relationship between the GATT dispute settlement system and that of international environmental agreements;
- environmental measures with an effect on trade, such as packaging, labeling, and marking requirements, product standards, and environmental taxes or charges; the relationship between market access and the environment (including tariff escalation)" (4).

Trade and environment issues are addressed further in chapter 5 of this report.

GATT (WTO)

The URA's provisions on agriculture have been touted as significant steps toward liberalizing global agricultural commerce. They cover a range of issues, including domestic subsidies, tariffs, import quotas, intellectual property rights, and certain health and safety standards. The new provisions require WTO members to eliminate all quotas, variable levies, voluntary export restraints (VERs), and similar nontariff barriers to agricultural trade, and replace them with tariffs. Accordingly, for the United States, all Section 22 quotas and Meat Import Act VERs must be converted to tariffs, which must be lowered by an average of 36 percent over six years (24 percent for developing countries) beginning in 1995. Tariffs on each category of imports must be cut a minimum of 15 percent (10 percent for developing countries). With regard to agricultural products that are currently subject to import quotas or bans, members must ensure that imports account for at least 3 percent of the base-period domestic consumption in 1995 and 5 percent by the year 2000. (An exception to

[11] The Tokyo Declaration can be found in (3).

BOX 3-2: Agriculture Provisions of the Uruguay Round Agre

IMPLEMENTATION PERIOD:
Six years, beginning in 1995 (1 O years for developing countries).

MARKET ACCESS:
Convert nontariff barriers (NTBs) to tariff equivalents, reduce tariffs by 36 percent on average, with minimum tariff cuts of 15 percent; require minimum access of 3 percent, expanding to 5 percent of base period domestic consumption levels for products covered by NTBs; maintain current access for products covered by NTBs with greater than 5 percent access; and establish special quantity-triggered and price-triggered import safeguards for agricultural products subject to tariffication. Base period for increased market access actions is 1986-1988.

EXPORT SUBSIDIES:
Reduce quantity of subsidized exports from 1986-1990 base by 21 percent; reduce budgetary outlays for export subsidies from 1986-1990 base by 36 percent, begin reductions from the higher of 1986-1990 average or, under certain conditions, the 1991-1992 average; make reduction commitments on a product-specific basis; impose budgetary disciplines on export subsidies for processed products; ban use of export subsidies for products not subsidized during the base period. Base period for export subsidies is 1986-1990.

INTERNAL SUPPORT:
Reduce total aggregate measurement of support by 20 percent, with credit for reductions made since 1986; establish criteria for non-trade-distorting policies; and provide criteria for production-limiting policies. Base period for internal support IS 1986-1988.

SANITARY AND PHYTOSANITARY MEASURES:
Base SPS measures on science, using risk assessment methodologies; encourage use of international standards but recognize the right to use stricter standards; require transparency in development and Implementation of SPS measures.

SPECIAL AND DIFFERENTIAL TREATMENT FOR DEVELOPING COUNTRIES:
Require lower reduction commitments for developing countries, equal to two-thirds of corresponding commitment for developed countries, to be Implemented over 10 years; exempt least-developed countries from reduction commitments. Base period for internal support actions is 1986-1988.

DUE RESTRAINT PROVISION:
Provides that policies that conform to the new disciplines and commitments on domestic and export subsidies are sheltered from international challenge under WTO/GATT during the implementation period.

SOURCE: U. S. Department of Agriculture, Foreign Agricultural Service, *Agricultural Provisions of the Uruguay Round,* Washington, DC, January 1994, p. 9.

this rule is Japan, which, instead of converting its ban on foreign rice to a tariff immediately, agreed to import 4 percent of domestic consumption in 1995, and 8 percent within eight years.)

The URA text on export subsidies follows similar lines. The major agricultural exporters (the United States and the EU) must cut their export subsidies by 36 percent in budget outlays, and by 21 percent in volume, within six years, using 1986-1990 as a baseline. With regard to domestic farm subsidies, the new agreement requires all members to reduce current domestic support to farmers by 20 percent over a six-year period (10 years for developing countries), using 1986 through 1988 levels as a base. Certain support programs deemed to have few or no adverse effects on

Recent congressional action on trade matters includes the North American Trade Agreement (NAFTA) and the Uruguay Round Agreements (URA). NAFTA will lower trade barriers between Mexico, Canada, and the United States while the URA will ease trade barriers and reduce export subsidies between a hundred or more nations.

trade—such as conservation measures, crop insurance, and extension programs—are exempted from this requirement, as are deficiency payments and food aid programs. Although deficiency payments are not considered to affect international trade patterns adversely, their impact on production patterns in the United States suggests that U.S. exports may be skewed in favor of the crops covered by target prices. Thus, while the United States is free to continue target price programs under the URA, their effects on domestic production patterns and export composition raise questions about the wisdom of using them.

Health and safety issues associated with agricultural trade generally fall under the rubric of "sanitary and phytosanitary" (SPS) measures, which include regulations to protect human, animal, or plant life and health from disease, nonindigenous species, dangerous levels of pesticide use, and so forth. Traditionally, GATT's article XX exempted from GATT rules domestic measures "necessary to protect human, animal, or plant life or health"-a description that includes most SPS measures. However, the URA emphasizes that members may employ SPS measures "only to the extent necessary to protect human, animal, or plant life or health" and must use SPS measures that are "least restrictive" to trade. The text also stipulates that SPS measures cannot generally be maintained "without sufficient scientific evidence." An exception permits countries-under certain circumstances in which scientific evidence is not available—to set SPS standards that are not based on scientific evidence. Technical regulations and standards, such as packaging and labeling requirements, must conform to similar rules.

Finally, the URA establishes the WTO, which, as noted above, has now taken on the GATT agenda and other responsibilities. Perhaps most germane for agricultural trade, the WTO has much stronger powers with regard to trade disputes than GATT did. Under the WTO, panel decisions hold unless there is a unanimous member vote against them. Under the old provisions, panels of experts were convened to resolve disputes between members, but authority to enforce decisions was extremely limited. Any GAIT member could, in fact, block a panel decision, and GATT could not actually enforce the decisions of its panels. Its only prerogative was to grant permission for the complaining nation to use trade sanctions against an offending nation if the latter did not comply with the GATT panel ruling. Under the new provisions, a defending party:

> . . . cannot block the formation of a panel and strict time limits are imposed for each step of the process. Once the panel has issued a report it will no longer be possible for wither party to block adoption of the report . . . Perhaps the most significant improvement in the process is that the complaining party will be given the right to retaliate if the offending party does not implement the recommendations of the panel within the agreed or arbitrated time limits (14).

One result of the URA is much stronger provisions for enforcement of panel decisions.

WORLD TRADE ORGANIZATION

Negotiations under the Uruguay Round went on for 7 years, covering Presidents Reagan, Bush, and Clinton. The negotiations ended in December 1993 and Congress gave final approval for the massive agreement in December 1994. Most of the URA provisions will be implemented by 2000.

■ NAFTA

Agricultural trade was not the defining issue in the NAFTA negotiations that it was in the Uruguay Round talks. Nonetheless, the United States, Canada, and Mexico remained deadlocked for months over many of the same issues: domestic agricultural practices and other NTBs. At the behest of Canada, which sought to preserve its supply management system in dairy and poultry products, as well as its subsidies for transporting grain, two separate agricultural market access agreements were negotiated: between the United States and Mexico, and between Mexico and Canada.[12] The United States and Canada agreed that they would continue to abide by the U.S.-Canada FTA's agricultural trade provisions.

Unlike the URA, which simply reduces tariffs on many of the agricultural goods traded among its members, NAFTA completely phases out North America's regime of agricultural tariffs. The time period for the tariff phase-out depends on the crop or product. For example, tariffs on about one-half of the agricultural products traded between the United States and Mexico were eliminated on January 1, 1994, when NAFTA came into effect. However, tariffs on extremely "import-sensitive" agricultural exports-products that have traditionally required substantial legislative

[12] As noted previously, Canada eventually agreed to dismantle its supply management system and its NTBs for dairy and poultry under the URA.

protection from imports—are phased out over 15 years. Import-sensitive products include corn and beans for Mexico, and orange juice, peanuts, and sugar for the United States.

NTBs, such as import quotas, are handled in a slightly different manner. Under NAFTA, the United States and Mexico must convert them either to ordinary tariffs, which are phased out according to the agreed-upon tariff schedules, or tariff-rate quotas (TRQs). In opting for a TRQ, either Mexico or the United States may allow a specified amount of duty-free imports of a certain good, and impose a predetermined tariff (equal to the estimated value of the preexisting NTB) on all imports above that amount. The specified amount expands, and the tariff is lowered, until all imports are duty free. NAFTA also provides "safeguards" against trade surges for selected products, which means that if imports exceed a specified level for a specified product, the importing NAFTA country may levy short-term tariffs on that product. The specified "trigger" levels increase over a 10-year transition period. Such products include live hogs (Mexico) and fresh tomatoes imported between certain dates (United States).

Although such provisions generally apply to industrial products, NAFTA requires that certain agricultural products meet a rules-of-origin test—that is, to qualify for NAFTA's preferential rates, these products must be entirely grown or substantially processed in a NAFTA country. As an example, the peanuts used in making peanut butter that is traded between Mexico and the United States must all be grown in a NAFTA country; and traded sugar must be grown and refined in a NAFTA country.

NAFTA's position toward domestic agricultural subsidies, as well as export subsidies, is considerably less stringent than that of the URA. With regard to domestic supports, NAFTA simply exhorts members to "endeavor to work toward support measures that (a) have minimal or no trade-distorting or production effects; or (b) are exempt from any applicable domestic support reduction commitments that may be negotiated under the GATT." The agreement also recognizes that export subsidies are "inappropriate," except as a means of countering subsidized exports from countries outside the NAFTA group. Consequently, the NAFTA text includes several measures that address the issue: for instance, a NAFTA exporter must give another NAFTA country at least three days' notice before introducing an export subsidy.

Quality and SPS standards were an important part of the NAFTA negotiations. The final NAFTA text, for example, allows the United States to continue using marketing orders—specifications regulating quality, cosmetic appearance, and as a result, quantity and price—for fruits and vegetables. However, the agreement also states that when they institute such measures, the United States and Mexico must offer no-less-favorable treatment to "like" products that are imported for processing. With regard to SPS standards, NAFTA upholds each party's right to choose and maintain the SPS measures it deems appropriate for its needs. The measures must, however, be grounded in scientific principles and risk assessment, must not constitute a disguised barrier to trade, and should be used only to the extent required to attain a country's chosen protection level. NAFTA's treatment of labeling and packaging requirements follows similar lines. These areas are discussed further in chapter 5.

Given that agricultural trade has been a particularly contentious issue in North America of late, the NAFTA dispute resolution provisions are key to the ultimate success of the agreement. Like the WTO, NAFTA relies on panels of trade and economic experts to settle potential disputes among members, and allows for consultation with experts in other disciplines. The agreement also creates a trilateral commission on agricultural trade that will monitor how the NAFTA agricultural provisions are implemented and administered.

IMPLICATIONS OF GATT AND NAFTA

A major difference between the URA and NAFTA is that limits on export subsidies are included in the URA. Export subsidies assumed a much greater importance under the URA because of its broader coverage. During the URA negotiations, export subsidies escalated as the United States and the EU vied for a nearly stagnant world market.

TABLE 3-2: Export Subsidy Commitments of the United States, European Union, and Canada Under the Uruguay Round Agreement

Outlay commitment	U.S.$1,000	EU1,000 ECU	Canada C$1,000
Wheat & products			
1995	765,490	2,069,400	311,000
2000	363,815	1,141,100	199,000
Rice			
1995	15,706	58,100	NA
2000	2,369	39,600	NA
Coarse grains			
1995	67,735	1,296,700	116,000
2000	46,118	882,900	75,000
Meat (beef, pork, poultry)			
1995	21,377	2,300,800	NA
2000	37,874	1,468,400	NA
Dairy products			
1995	185,626	3,046,600	126,500
2000	116,618	2,011,400	80,800

SOURCE:International Agricultural Trade Research Consortium (Tim Josling, et al), "The Uruguay Round Agreement on Agriculture An Evaluation, " Commissioned Paper No 9, University of Minnesota, St Paul, Minnesota, July 1994

Both governments tried to position themselves for maximum negotiating advantage. Under the final agreement, all countries that use export subsidies will gradually lower their use. The levels negotiated by the United States, the EU, and Canada, the three largest subsidizers, are summarized in table 3-2 for major commodities for 1995 and 2000.

The amount of subsidies negotiated and the amount specified in the individual country schedules submitted to GATT were measured in each country's currency, which makes comparisons among countries more complicated. To overcome this difficulty, subsidies for 1995 and 2000 were converted into U.S. dollars using exchange rates from November 1994[13] and are shown in table 3-3. Wheat export subsidies are the largest for the United States and Canada, while dairy subsidies are the largest for the EU, followed by meat, wheat, and coarse grains. Levels of export subsidies for wheat and wheat products will be cut nearly in half between 1995 and 2000 for all countries. For coarse grains, the reduction is not as large (about one-third). For meat, the EU will remain a large subsidizer even in 2000, as it will for dairy products.

The amount of agricultural export subsidies allowed for 2000 are lower for all countries and all commodities. An overall reduction of 36 percent was agreed to by Canada and the EU, while the United States agreed to a reduction of 49 percent. Some variations among commodities and within commodity groups were evident in the final U.S. subsidy numbers, although the differences are not extreme. With regard to dairy products, for example, there were large reductions for some items and smaller reductions for others. U.S. wheat subsidies were lowered more in percentage terms than coarse grains, but the total amount of subsidy for wheat was much larger. Export subsidies for rice were cut significantly, but some offset was provided by the marketing loan program, which allows growers to repay their price support loans at world market prices, then sell their rice for either domestic consumption or export at lower prices and still cover costs of production. Examined from this perspective, the marketing loan program is another form of export subsidy. It is available

[13]On November 9, 1994, the ECU traded at 1.2599 U.S. dollars and the Canadian dollar traded at 0.7375 U.S. dollars, according to the *Wall Street Journal,* p. C 16.

for crops other than rice, although USDA has chosen not to implement it for them.

Export subsidies are only a part of total outlays for agricultural commodities. In addition, producers in the United States and the EU receive production payments that offset lower market prices. These payments act as indirect export subsidies although, because they are available to internal buyers as well as export buyers, they are not technically export subsidies. Neither U.S. deficiency payments nor the new compensation payments under the reformed CAP had to be lowered under the terms of the URA.[14] Each country must establish a ceiling for the amount of support afforded producers through internal support mechanisms. Average support provided to producers for all commodities must be less than levels extended for the 1986-88 period. Since payments have declined in the interim years, this leaves open the opportunity for both countries to provide larger income support payments in the future. However, since income support payments cover a large portion of total production, costs are considerable and may act as a constraint on their use, given budget limitations in both the United States and Europe.

The URA allows other types of indirect export subsidies to continue. Schott (4) outlines the details:

> The agreement expressly excludes several types of export subsidy programs from the new disciplines. Export credits, credit guarantees, and insurance programs are not covered, but governments commit themselves to develop and adhere to internationally agreed disciplines in these areas. In addition, privately financed export aid is not covered as long as it is not mandated or arranged by the government or extended to products receiving other governmental support. This provision ensures that those producer-financed export subsidy schemes that provide benefits comparable to those under similar government programs are subject to GATT disciplines. Food aid programs were also excluded from coverage. This exemption could become important if countries redefine export shipments to countries in economic or environmental distress.

Besides the URA, the United States is also implementing the terms of NAFTA. Will the two agreements help the United States to compete more effectively in the world market for food and agricultural products? They are projected to do so, albeit modestly. According to USDA, the URA is expected to boost U.S. agricultural exports by $1.6 billion to $4.7 billion in nominal terms by 2000 (3.8 to 11.0 percent increases over 1993 exports of $42.6 billion), and between $4.5 billion to $8.7 billion by 2005 (13). Farm income is expected to be $1.1 billion to $1.3 billion higher than would otherwise be the case in 2000 (2.4 to 2.8 percent increases over 1993 net farm income of $45.5 billion), while government outlays are projected to decline by $0.7 billion to $1.3 billion (4.4 to 8.1 percent decreases over 1993 government outlays of $16.0 billion). In 2005, farm income is projected to increase by $1.9 billion to $2.5 billion, and government outlays could decline by $2 billion to $2.6 billion (13).

Estimates from other organizations, although they project expanded trade, are less optimistic. The U.S. International Trade Commission (ITC), for instance, concludes that "because the Uruguay Round agreement will increase both export opportunities and the level of imports for most agriculturalsectors, the overall net trade effects are likely to show negligible to modest gains at the sector level." As a result of the URA, the ITC projects small (1 to 5 percent) increases in exports of livestock, meat, poultry, and eggs; modest increases (5 to 15 percent) in exports of such bulk commodities as grains, as well as in fruits and vegetables; and "sizable" increases (more than 15 percent) in dairy products and beverages (18). Also according to the ITC, U.S. agricultural exports of grains and

[14] In 1992, the EU reformed the CAP, instituting mandatory set asides to lower output and compensating European farmers with government payments that are based on the hectares of crops planted, not on the level of output. U.S. target price payments are based on acreage and yields although the yields are frozen at 1985 levels. Flex acre provisions provide additional limitations with payments limited to 85 percent of the base acres on a farm.

TABLE 3-3: Export Subsidy Commitments Converted into Dollars for the United States, European Union, and Canada Under the Uruguay Round Agreement.

Outlay commitment	U.S.$1,000	EU$1,000	Canada$1,000
Wheat & products			
1995	765,490	2,607,237	229,363
2000	363,815	1,437,672	146,763
Rice			
1995	15)706	73,200	NA
2000	2,369	49,892	NA
Coarse grains			
1995	67,735	1,633,712	85,550
2000	46,118	1,1 12)366	55,313
Meat (beef, pork, poultry)			
1995	21,377	2,898,778	NA
2000	37,874	1,850,037	NA
Dairy products			
1995	185,626	3,383,841	93,293
2000	116,618	2,534,163	59,5900

SOURCE: International AgriculturalTrade Research Consortium (Tim Josling, et al), "The Uruguay Round Agreement on Agri culture An Evaluation, " Commissioned Paper No 9, University of Minnesota, St Paul, Minnesota, July 1994

oilseeds, certain fruits, poultry, and dairy products to Mexico are likely to increase modestly to considerably in the long term under NAFTA, while imports from Mexico will rise somewhat for frozen vegetables, citrus juice, and some fruits, such as strawberries, grapes, and melons. In an assessment somewhat similar to that of the URA, the ITC concludes that NAFTA "will likely have a minimal impact on overall U.S. agricultural competitiveness" (19).

Could the gains have been greater? A key factor would be whether internal subsidies, such as those that the EU and United States provides its farmers, are actually affected by the URA. In the final analysis, this appears not to be the case. The base years from which reductions in domestic farm subsidies are calculated (1986- 1988) represent a period in which the governments of both the United States and the EU lavished considerable sums on their respective agricultural sectors (through both production and export subsidies). Since that time, however, domestic budget woes, plus the easing of financial problems in U.S. agriculture, have led to reform of U.S. policies and forced the EU to launch reforms of the CAP. These reforms and reductions have lowered total outlays on agricultural programs considerably. Consequently, even though total outlays must be lowered by 20 percent under the URA, actual reductions will not be required.

In addition, and as noted earlier, the URA exempts a number of subsidies from its disciplines, such as conservation measures, crop insurance, and disaster programs. These programs are not considered to have adverse effects on trade because the payments do not ultimately support commodity prices. Included among them are general service programs such as research, extension, and pest and disease control, as well as inspection, market promotion, and infrastructure support. The result is an agreement on internal supports that is, according to Josling et al., "elaborate window dressing, but transparently nothing of substance" (6). The United States will not have to make additional cuts to comply with the URA, and the EU's concessions will be "relatively limited" (6). Reductions in export subsidies will also be modest, given ongoing CAP reform, although, notably, the United States will match the EU's ton-for-ton reductions in subsidized exports in wheat. By extension, it seems likely that, as Josling et al., point out, "the United States will . . . concentrate its export subsidy bonuses in those markets that continue to face subsidized competition from the EU" (6). Developments such as these may in fact serve to draw U.S. attention and dollars to promoting high-value products, although the process may be slow and incremental. In its report on the URA, the ITC noted that U.S. exports of such high-value products as fruits and vegetables, poultry, livestock and meat, beverages, and certain specialty items may benefit from new provisions in the URA's SPS agreement.[15]

Because both the URA and NAFTA lower and/or eliminate tariffs and traditional NTBs such as quotas, some have speculated that member countries may compensate by using their SPS regulations as barriers to agricultural imports. Kuo and Yanagisawa contend, for example, that both Japan and South Korea may seek to protect their newly opened rice markets by imposing discriminatory safety standards on post-harvest chemical treatments of rice (8). Such uses of health and safety standards are not new: the EU's Third Country Meat Directive and its ban on meat products from animals given certain hormones are cases in point.

In a related matter, packaging and labeling requirements that fall under the aegis of "environmental" measures have increasingly been the subject of disputes involving such products as traded beverages. Whether high-value U.S. agricultural exports would be significantly impeded by a global increase in SPS and "environmental" measures used as trade barriers is not yet clear, but remains a possibility—and the ability of the WTO or NAFTA to effectively and consistently prevent the use of SPS and environmental measures in this manner has yet to be determined. These subjects are discussed further in chapter 5.

TRADE AGREEMENTS AND DOMESTIC PROGRAMS

Although the URA will have little direct influence on the level of domestic subsidies that the United States and the EU give their farmers, it seems likely that the new trade agreements, along with ongoing budgetary pressures, will exert pressure to disengage from the elaborate system of farm support mechanisms that both countries currently have in place. Lower tariffs and the process of converting certain NTBs to tariffs will bring more competition from outside suppliers. Price supports may again act as incentives for other countries to ship more products to the United States. Target price programs may become more costly as foreign supplies lower global and internal market prices, expanding the differential between target and market prices and increasing the level of budgetary payments.

The United States has already taken steps to correct some problems that have grown out of the increased globalization and greater trade orientation of the past two decades. An example is the creation of flex acres in the 1990 farm bill, a step that was designed to lower budgetary cost and reverse the decline in U.S. soybean acreage. The decline was the outgrowth of complex interactions between the economics of domestic farm programs and the expansionary tendencies of foreign suppliers. (See box 3-3.) But the result was more soybean acreage in Brazil and Argentina and less acreage and fewer exports of soybeans and soybean products from the United States.

Beyond the internal problems, current farm programs also have led to external problems. One very visible problem has been the matter of wheat imports from Canada. The problem revolved around a U.S. target price for wheat that encouraged more wheat production than markets would absorb without large export loans and export subsidies. These programs expanded exports and raised the domestic price of wheat, drawing in wheat from Canada. Before the U.S.-Canada FTA was implemented, such shipments were discouraged by threats of Section 22 actions. Under the FTA, however, Canada had the opportunity to ship wheat into the United States. Although technically permissible, the shipments led to tensions between the two countries, as U.S. wheat farmers saw the benefits of export expansion programs si-

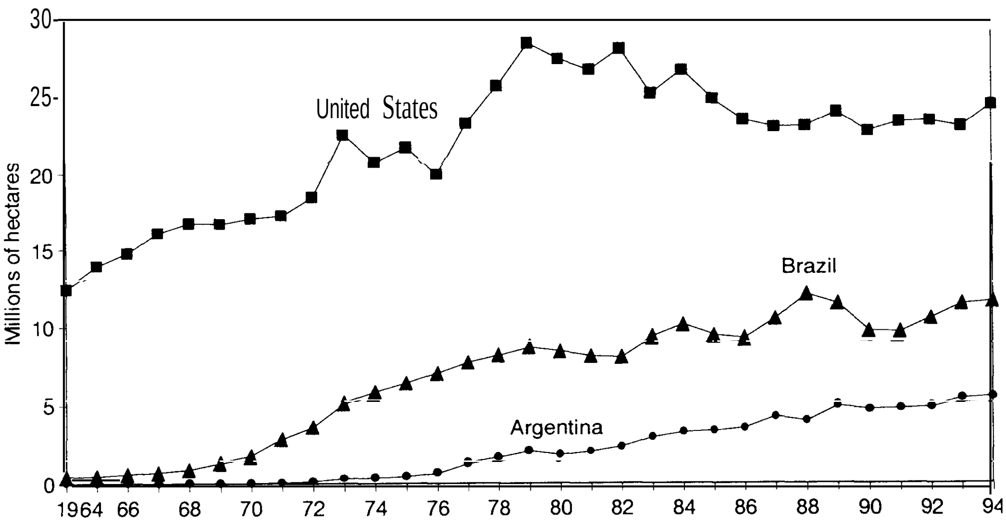
[15] The agreement provides for "mutual acceptance of national inspection systems and adoption of a "regionality" provision that permits exports from certified disease-free areas within a country" (18).

BOX 3-3: The Soybean Situation

Soybeans, like all crops, must compete for available cropland. As part of this competition, farmers compare expected returns per acre from other crops with expected returns from soybeans. In making these comparisons, farmers take into account that wheat, corn, other feed grains, rice, and cotton are covered by both price support programs and deficiency payments under target price programs. Soybeans are covered only by price supports

The availability of price supports and, since 1973, target price payments for other crops, favors the production of other crops over soybeans This is especially true across the Corn Belt, where yields of corn have Increased relative to soybean yields As corn yields rose and production exceeded market requirements, acreage reduction programs were Instituted to hold down total output of corn and other program crops As a portion of the nation's cropland was idled, less acreage was left for soybeans, which contributed to a downward trend in soybean acreage From a high of 72 million acres of soybeans planted in 1979, U.S. soybean acreage declined and totaled 61 million acres in 1994, while acreage in other countries continued to rise (figure 3-4).

FIGURE 3-4: Area of Soybean Harvest, 1964-1993



SOURCES U S Department of Agriculture, Economic Research Service, Production, Supply and Demand Database, 1994

In an effort to reverse the downward trend in soybean acreage, the 1990 farm bill provided that soybeans could be planted on a portion of acreage previously devoted to corn and other major program crops without loss of future eligibility for target price payments. This flexibility provision, along with unusual weather conditions, ended the downward trend in soybean acreage. Modest increases occurred in 1991 and 1992, with more than 59 million acres planted. Acreage Increased to 60 and 61 million acres for 1993 and 1994, respectively—although some analysts argue the increase may have been due to the extremely wet spring and fall of 1993, which prevented plantings of other program crops. The added flexibility is not given much credit for the increased acreage. Soybean acreage is not expected to increase very much unless further changes are made in current farm legislation.

SOURCE Office of Technology Assessment, 1995

phoned off to a competitor country. After several years of dispute, the United States requested in 1992 that a dispute settlement panel be setup to resolve the issue. Some aspects of the case were clarified-but the fundamental conflict remains, even though the URA will further limit the use of restraints on wheat imports.[16]

16 For an extended review of the U.S.-Canada trade dispute over wheat, see (12).

As the URA is implemented over the next several years, other conflicts between the new agreements and old farm program regulations are likely to arise. Similarly, there may be more conflicts between the old programs and new global market trends. Two examples where current program regulations are in conflict with global market trends are the prohibition on planting of fruits and vegetables on flex acres and the prevention of grazing on Conservation Reserve acres. Both tend to hold down production of items that are in growing demand in world markets. While they may have been well intentioned when initially established, the new trends in global markets have made both of questionable value to the nation.

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Agriculture's Broadening Environmental Priorities 4

Covering nearly half of all the land in the United States, farms and ranches have a profound effect on the nation's environment. The quality of water and wildlife habitat—and indeed, the continuing productive capability of soil itself—depend on how farmers and ranchers manage their land, and how the environment responds to their management techniques.

Research and monitoring of agroenvironmental conditions—those produced by the interaction of agricultural and environmental systems—provide some broad evidence of agriculture's role in the quality of soil, water, and wildlife resources. The first section of this chapter reviews the evidence, which indicates that some agricultural practices have had a significant impact on the nation's environment. While, on the one hand, erosion of cropland has decreased significantly for several decades, agriculture remains the nation's primary contributor to surface water pollution, principally because of sediment deposition and agrichemical runoff from dryland and irrigated systems. Nitrate from fertilizers used in agricultural production have leached into and contaminated groundwater, exceeding federal drinking water standards in many agricultural areas. Comprehensive monitoring of agricultural pesticides in groundwater is not yet available, but some state studies focused on agricultural areas indicate concentrations in excess of drinking water standards do occur. Further, observations of wildlife show that impaired water quality as well as agricultural land uses can degrade the quality of habitat of aquatic, wetland, and terrestrial species. Indeed, agricultural practices have been linked with at least one-third of endangered species and with the extinction of species. But conservation programs introduced in the mid 1980s have also significantly increased some species populations.

It is important to note that at this time, a comprehensive assessment of agriculture's effects on environmental quality is not possible, because agroenvironmental monitoring is incomplete and the interactions between agricultural activities and the environment are not well understood. There is a pressing need not just for more research, but for more sophisticated agroenvironmental science to clarify the functioning of agroenvironmental systems, describe their conditions, and interpret the environmental implications of those conditions.

The second half of this chapter focuses on the basic approaches the federal government is using for both known and emerging agroenvironmental problems. Currently, Washington gives incentives to farmers and ranchers to adopt conservation and environmental technologies through several different kinds of programs. Voluntary educational and technical assistance programs, which came into being during the Great Depression, have remained one of the government's chief vehicles for doing so—even though there is a lack of scientific evidence to indicate that without subsidies, such programs lead to significant environmental improvements. Subsidy programs have produced conservation and environmental gains, but generally have not been targeted to areas of greatest environmental significance and have not always encouraged cost-effective practices. Further, they are increasingly vulnerable to budget-cutting pressures. Compliance schemes, a landmark development of the 1985 Food Security Act, link environmental performance on high erodible lands and wetlands to receipt of agricultural program payments. Regardless of their efficacy to date, the schemes suffer two basic shortcomings—the size of the compliance penalty and thus the size of the incentives to implement the conservation plan may not align with environmental priorities, and their longevity depends upon continued renewal of agricultural program benefits.

Environmental regulations also affect several types of agricultural activity, although less so than for other industries. However, the perceived impacts of regulation are broad, perhaps because several new efforts have begun over the past two decades. Pesticide registration involves a protracted and costly review process that is behind schedule and has created impediments to innovation. Problems in reregistering compounds for minor use crops with small pesticide markets exemplify the costliness, prompting recent administrative improvements. Farmers applying for permits to alter wetlands for agricultural purposes have also met with time delays, although the delays are improving. Water pollution controls for confined animal operations have not been uniformly enforced. Treatment of agricultural pollutants in coastal zones is still in the planning stages; endangered species protection within the agricultural sector is largely undocumented; and imports of harmful nonindigenous species accompanying expanded trade are covered by an incomplete set of regulations. The prospects of future potential regulatory efforts are likely contributing to the broadly perceived impacts of regulation.

Taken as a whole, the incremental institutionalization of at least 40 separate federal agroenvironmental programs, with no comprehensive oversight, has meant that there is no clear set of environmental objectives and priorities for the agricultural sector. Clarifying agriculture's environmental responsibilities, and the public and private roles in accomplishing those objectives, would reduce uncertainty for all sides and allow scarce public resources to be focused on high priorities.

Given the potential scope and long-run seriousness of many poorly understood agroenvironmental interactions, and given the various problems that persist in many government programs, the future environmental agenda for agriculture must accommodate incomplete science, while also promoting research and program incentives for achieving agricultural production and environmental quality simultaneously. Interest in such "complementarity" between agricultural production and the environment has grown within the research community, among farm producers, among agribusinesses, and among consumers. Technological research and development aimed at enhancing such complementarity holds considerable promise to achieve improved environmental quality while maintaining competitiveness. Nonetheless, the low level of federal funding for agroenvironmental research and lack of major program goals to enhance such technology will slow the reorientation of public research priorities from traditional production emphases to complementary technologies.

AGRICULTURE AND ENVIRONMENTAL QUALITY

Since the 1960s, public awareness of the links between agricultural practices and the environment, and evidence that those links can have serious implications for both human and environmental health, has been growing. Consequently, federal and state legislation has increasingly been aimed at ensuring that farming practices balance output goals with soil, water, and other environmental quality objectives. Wetlands, which were once considered undesirable swamps, are now recognized for their contributions to water quality, flood control, and habitat. Erosion control, once pursued mainly to preserve crop yields, now plays a strong role in reducing water pollution from sediment and agrichemical runoff. Some agricultural lands are cultivated for crop production while also protecting wildlife habitat.

The environmental effects of agriculture may be re-evaluated when residential and agricultural activities come in close proximity. For example, localized leaching of farm chemicals into groundwater may be perceived as more harmful if that aquifer becomes the primary source of public drinking water in new residential areas. The environmental effects of long-standing farm practices such as aerial pesticide applications or hog production may also be redefined by the proximity of residential and agricultural lands.

Despite growing evidence of agriculture's effects on the nation's environment, the nature of the effects are not sufficiently documented. At this writing, many federal programs independently monitor natural resources, but their data are not designed to be integrated into an overall assessment. No federal databases comprehensively evaluate national water quality conditions, trends in soil quality (except erosion), or agriculture's effects on wildlife. Moreover, federal programs do not address many of the biological, chemical, and physical links between agricultural practices and environmental conditions. Indeed, many agrichemicals have not been evaluated fully for their potential effects on the health of humans or environmental systems. The National Research Council (NRC) has noted that the nation's agroenvironmental research agenda is too poorly funded (about 12 percent of the total agricultural research budget) and lacks focus (65).

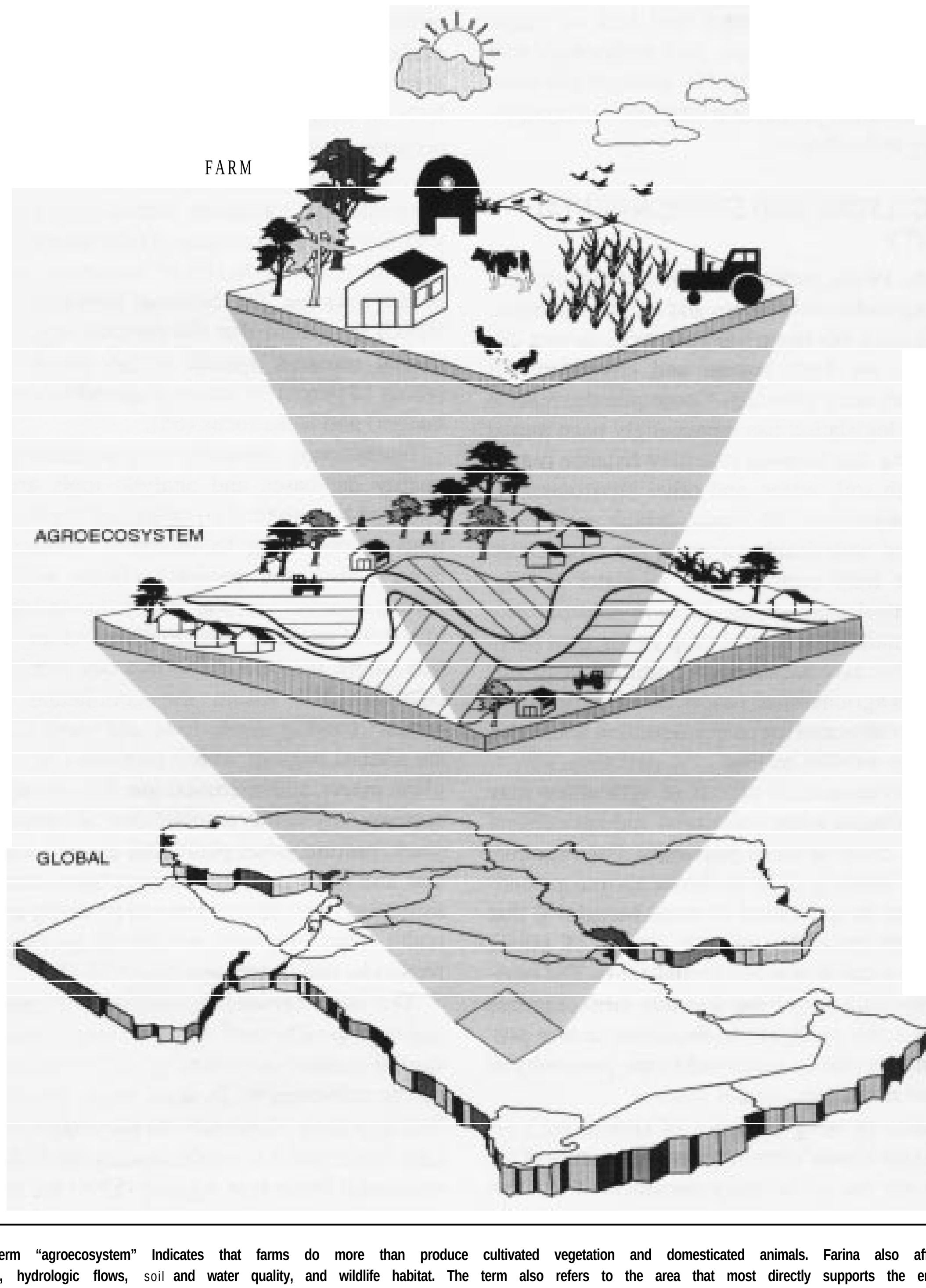
Institutional obstacles to constructing high-quality databases and analytic tools are compounded by technical complexities, such as variations in prevailing technologies, cultural practices, policy and program effects within and among regions—and the sheer range and diversity of natural resource endowments. As an illustration, more than 2,111 distinct watersheds have been mapped within the continental United States.[1] Cutting across land and water divisions are natural habitats with a profusion of wildlife, plant, insect, and microbial life. Diverse agroecosystems—dynamic associations of crops, livestock, pasture, other plants and animals using air, soil, and water span this resource base, encompassing nearly one billion acres of privately and federally owned cropland, woodlands, grazing lands, wetlands, and waterways (figure 4-1).

The links between environmental conditions and biological health[2] implications are a matter of special concern in evaluating agriculture's effects on the environment. In some cases, this link has been expressly addressed: the maximum contaminant levels (MCLs) established by the U.S. Environmental Protection Agency (EPA) are used for monitoring drinking water quality to protect hu-

[1]A watershed is an area of land from which water drains to a stream or to a lake, wetland, or reservoir.

[2]Biological health, as used in this report, refers to the viability and safety of plants, wildlife and humans.

FIGURE 4-1: Agroecosyste



The term "agroecosystem" Indicates that farms do more than produce cultivated vegetation and domesticated animals. Farina also affect nutrient cycling, hydrologic flows, soil and water quality, and wildlife habitat. The term also refers to the area that most directly supports the environmental and productive functions of farms and, conversely, in which most environmental effects of production-such as sediment deposition, modification of wildlife habitat, or changes in water quality-are likely to be detected.

SOURCE: Adapted from EPA Environmental Monitoring and Assessment Program (EMAP), 7992 *Agroecosystem Pilot Project Plan (EPA/620/R-93/010),* January 1993.

TABLE 4-1: National Surface Water Quality, 1992

Water	Total resource base[a]	Percent assessed	Percent impaired of assessed	Percent of assessed that fully support designated uses	Rank of agriculture as source of pollutants
Rivers and streams	3.5 million miles	18	38	56	1 - primary source
Lakes, ponds, reservoirs	40 million acres	46	44	43	1- primary source
Great Lakes shoreline	5,382 miles	99	97	2	NA[b]
Ocean shoreline	56,121 miles	6	14	80	NA
Estuaries	36,890 sq. miles[c]	74	32	56	3- notable source[d]
Wetlands	277 million acres	4	50	50	1 - primary source

NA - Not Available.

[a] Contiguous United States and Alaska.
[b] Atmospheric deposition is ranked first.

[c] Not including Alaska.
[d] Municipal point sources and urban runoff are ranked first and second.

Percent impaired plus percent fully supporting may not sum to 100. The difference is comprised of "threatened" waters—those that are now fully supporting but at risk of impairment.

SOURCE: EPA, National Water Quality Inventory, 1992 Report to Congress

man health. In general, however, standards that link environmental quality and biological health are tentative or nonexistent, a result of inadequate science, incomplete policy guidance, and the complexity of the issues.

▮ Primary Elements of Natural Resource Quality[3]

Surface Water Quality

As a result of normal farming practices, soil sediment, pesticides, nutrients (nitrate and phosphorous), toxic metals, and pathogens can and do make their way into the nation's surface waters (rivers, streams, lakes, ponds, wetlands, and estuaries). Water quality data collected by the Environmental Protection Agency (EPA) suggests that the majority of the nation's surface waters that were assessed in 1992 were of sufficient quality to support one or more "beneficial use" designated by states[4] (table 4-1). However, EPA and state officials consider nonpoint source pollution[5] from agriculture to be the major contributor to remaining national surface water quality problems (120).

Although the federal government does not systematically monitor surface water quality conditions[6] and their environmental implications, agriculture's predominant role in polluting surface water-especially in regions where crops are intensively cultivated or where livestock operations are concentrated—is corroborated by numerous reports and studies conducted by government and independent researchers. The U.S. Geological Survey (USGS) recently found that 71 percent of U.S. cropland is in watersheds where at least one

[3] This review of agriculture's effects on the environment focuses on the three primary natural resource groups—water quality, wildlife, and soil quality. Discussion in chapter 6 covers the effects of air pollution on agricultural productivity. The potential effects of climate change on agricultural and environmental systems are covered in "Preparing for an Uncertain Climate," U.S. Congress, Office of Technology Assessment, 1993.

[4] Designated beneficial uses include aquatic life support, fish consumption, shellfish harvesting, drinking water supply, recreation (swimming and boating), and agricultural production (120).

[5] The term "nonpoint source" or "nonpoint" refers to the inability to trace pollution to a specific source or "point" of origin.

[6] USGS studies of water conditions, while consistently collected and extensive, are not designed to satisfy the need for comprehensive monitoring. State-reported data compiled by EPA do not represent a statistical sample, and moreover, are not consistently collected across states. They are, at most, suggestive of national surface water quality (120).

Rain and irrigation waters carry sediment and chemicals from cropland into surface waters. Drainage off fields, as shown above, or from underground tile empties into streams, rivers, lakes, or wetlands. The cumulative effect of drainage like this from many fields influences the quality of entire watersheds. Almost three-quarters of all U.S. cropland **lie** *in watersheds where levels of sediment, fertilizer residues, or bacteria from livestock manure exceed EPA guidelines.*

agricultural contaminant exceeds guidelines established by EPA for recreational safety or the ecological health of the water (83).

Several large-scale studies show that agriculture has played a significant role in supplying the nitrogen, phosphorus, and sediment found in the nation's surface waters (35,82,120). Crutchfield et al. (19) found that 50 percent of nutrients reaching freshwater systems nationwide come from agricultural runoff, and the U.S. Geological Survey's National Water Quality Assessment (NAWQA) sampling program confirmed that, in 90 percent of the watersheds studied, agriculture supplied most of the nutrients found in rivers and streams in rural areas (116). Evidence also indicates that the level of common agricultural pollutants in regional watersheds declined during the last decade (83).

The environmental implications of agricultural pollutants in surface water depend on how prevalent the pollutants are; how toxic they are to humans, aquatic life, and other wildlife; how chemically stable they are in water; and how mobile they are in water systems. Existing research as noted above suggests that agricultural pollutants are prevalent in surface water, especially in areas where land is cultivated intensively with mechanical tillage, and irrigation and/or chemicals are applied. Research on the toxicity of agricultural pollutants remains incomplete—nitrate and some pesticides are established toxins, but the vast majority have not been fully tested. It is not known how quickly nutrients and pesticides degrade in water, but field studies suggest that chemicals are more stable in water than in soil (37), and sediment does not degrade. Some agrichemicals and sediment can migrate long distances through rivers and streams. Volatile agrichemicals can be transported through the atmosphere and deposited with rain into surface waters far beyond their region of origin (39).

According to state reports, agricultural runoff of nutrients and sediment is a primary cause of "impairment" of lakes, ponds, wetlands, and estuaries (120).[8] High nutrient levels promote eutrophication, a condition of excessive algal growth that depletes dissolved oxygen in aquatic habitat and increases the incidence of fish kills. Buildup of sediment, known as siltation, reduces water quality for drinking or recreation, fills in bodies of water, reduces navigability, increases the likelihood of flooding, and interferes with the spawning (reproduction) of many kinds of fish. Annual damages from agricultural siltation have been estimated to be between \$3 and \$13 billion in 1980 (14) and between \$5 and \$17.6 billion in 1989 (101). The large range for damages reflects that both studies had to use preliminary and incomplete water quality and economic information.

Atrazine and other herbicides as well as insecticides are almost always detected in surface waters in regions where they are used (36,64,83,103).

[7] The contaminants monitored were suspended sediment, dissolved nitrate, total phorphorus, and fecal coliform bacteria (83).

[8] Estuaries are water passages where the sea tide meets a river current and contain brackish(mixed salt and fresh) water.

Within regions where fertilizer use and livestock are common, evidence of nitrate in surface water may vary considerably across the region (36). Herbicide and nitrate concentrations in surface water vary seasonally but, in many streams, agrichemicals may be detected year-round as they are slowly released from storage in surface water reservoirs, groundwater, and soil (36,54,76). The seasonality of insecticide concentrations is similar to that for herbicides, but, compared to herbicides, insecticides in surface water are less persistent, concentrations are lower, and peak concentrations occur later in the season (36).

While nitrate levels peak in fall, winter, and early spring, herbicide concentrations tend to peak in the late spring and early summer when heavy rains wash agrichemicals from newly treated fields. During this "spring flush," herbicide levels in streams and rivers often exceed EPA drinking water standards expressed as MCLs (appendix 4-1). Atrazine has been measured at more than 30 times the MCL in some Midwestern streams and more than 3 times the MCL in large rivers (37).[9] In most cases, nitrate and herbicide levels fall to within federal standards by late summer, as agrichemicals are utilized, degraded in riverbed sediment, stored in soil or groundwater, volatilized into the atmosphere, or carried downstream.

The stability of agricultural pollutants in water enhances the likelihood that when agricultural pollutants disappear from flowing waters in the regions where they originate, they may be transported to coastal zones, lakes, wetlands, or reservoirs. Indeed, researchers found that agriculture supplied an average of 24 percent of total nutrients and 40 percent of total sediment in 78 estuarine systems (18). At least one herbicide was detected in 92 percent of the reservoirs sampled in 10 midwestern states between April and November of 1992.[10] Perhaps the best known example of the mobility of agricultural pollutants involves California's Kesterson Wildlife Refuge where accumulations of selenium carried in irrigation flows draining into the refuge poisoned waterfowl and made the wetland uninhabitable.

Recent monitoring showed generally less than 3 percent of each herbicide applied on farms in the Mississippi Basin and the equivalent of 15 percent of all nitrogen fertilizer used on regional crops enter the Gulf of Mexico from the Mississippi River. These percentages equate to 123 and 321 metric tons, respectively, of common herbicides like metolachlor and atrazine and 967,000 metric tons of nitrate (6). Tributaries from Iowa, Illinois, and Minnesota were determined to be significant sources of agrichemicals transported to the Gulf, illustrating that agricultural pollutants can remain stable and mobile over long distances. Similarly, diazinon, a spray pesticide used on orchards in the Central Valley of California, has been detected throughout the Sacramento-San Joaquin Delta and San Francisco Bay, in concentrations that exceed aquatic health recommendations established by the National Academy of Sciences (114).

Reservoirs and large lakes that are slow to recharge (i.e., where water replacement takes 6 months or more) can become "sinks" for agricultural pollutants transported seasonally by streams, rivers, and the atmosphere. Reservoirs sampled in 1990, 1991, and 1992 held atrazine levels that exceeded EPA drinking water standards even in winter months, when chemical concentrations would be expected to be at their lowest (38). Agrichemicals, such as DDT, atrazine, and alachlor, which can volatilize into the atmosphere and be deposited with rainfall, may accumulate in reservoirs and have been detected in all of the Great Lakes (box 4-1) (39,80). Herbicide residues can pose a

[9]Maximum contaminant levels (MCL), or drinking water standards, have been established by the U.S. Environmental Protection Agency for several herbicides and nitrate (see appendix 4-1). MCL's for herbicides are based on an annual average of four or more samples and are legally enforceable under the Safe Drinking Water Act. The MCL for nitrate is based on a single sample and not an annual average. MCL's have been established only for individual compounds and do not address the possible effects of complex mixtures of pesticides and their degradation products.

[10]Illinois, Indiana, Kansas, Minnesota, Missouri, Nebraska, North Dakota, Ohio, South Dakota, and Wisconsin.

BOX 4-1: Surface Water Quality

Persistent Contaminants in Freshwater Sources: Great Lakes

Toxic agrichemicals remain in the Great Lakes surface waters despite strenuous efforts at remediation and despite significant reductions in industrial sources of pollution In the Great Lakes basin, which holds 21 percent of all the fresh water on earth (1 0,80), concentrations of toxic contaminants generally went down between the 1970s and 1980s, Decreased concentrations of agricultural pesticides, especially organochlorines such as dieldrin and DDT-related compounds, in fish tissue are considered a key indicator of that trend However, the decline in contaminants leveled off in the early 1980s, leading scientists to reconsider the Iikely behavior of waterborne pollutants within the Great Lakes environment

Several causes for the chemical persistence have been observed, Some chemicals, notably DDT, are extremely persistent (i e , resist degradation). Toxins that are bonded to bottom sediment are remobilized by dredging or by the natural shifting of the lake bottoms, Slow leaching of contaminants from a variety of sources continues Chemicals from agricultural runoff and industrial or municipal effluent are transferred from tributaries. Volatile pollutants are transported across regions and even continents through the atmosphere and deposited through rainfall into the Great Lakes, Finally, water in the Great Lakes has an extremely long residence time. It will take a full century for the water currently contained in Lake Michigan to be naturally filtered and replenished; in the case of Lake Superior, volume replacement will take 172 years (79), As a result, these lakes are vulnerable to the cumulative effects of runoff, atmospheric deposition and the persistence of the contaminants which they contain

Atrazine has been detected in Lake Superior in pristine Iocations that are inaccessible to all migration pathways except for the atmosphere (39) In fact, atmospheric deposition ranks as the primary source of pollutants in the Great Lakes (1 20) Some of the persistent agrichemicals were banned in the United States as much as 15 years ago but are believed to enter the Great Lakes Basin through the atmosphere Others are manufacturing residues of pesticides that were never actually in use in the Great Lakes basin at all but manufactured in the region for export.

Independent and synergistic effects of pesticide contaminants, primarily on wildlife and human health, are still being investigated. Reproductive failures, developmental abnormalities, morphological abnormalities, and tumors in wildlife have been Iinked to agrichemicals, byproducts of agrichemical production, and their breakdown products (10) Some of the species known to be affected by persistent contaminants in the Great Lakes include mink, otter, double-crested cormorant, herring gull, snapping turtle, lake trout, and bald eagle (10)

Persistent Agrichemicals in the Great Lakes

Compound	Agricultural uses	Use status	Pathway to Great Lakes basin
Mirex	insecticide	canceled 1976	release during manufacture
Hexachlorobenzene	fungicide	canceled 1990	atmospheric deposition
Dieldrin	soil Insecticide	canceled 1971	leaching
DDT/DDE	insecticide	canceled 1971	atmospheric deposition
Toxaphene	cotton crop insecticide	canceled 1982	atmospheric deposition

Source" Office of Technology Assessment, 1995 special problem for public water supplies that draw from surface waters because conventional water treatments cannot remove them.

Wetlands are recognized best for their role as wildlife habitat, but they also function as surface waters, acting as a sink and filter for agricultural pollutants, and serving as flood storage and control areas. The economic significance of these surface waters extends beyond water quality and has been estimated in the billions of dollars for the recreation, timber, and trapping benefits that they provide (42,92). Today, about 5 percent of the lower 48 states are comprised of wetlands falling from about 10 percent in 1780 (21). Very little data has been collected to describe the quality of wetlands or their roles in attaining improved surface water quality, however. According to EPA, states (which are responsible for monitoring water quality and for monitoring wetlands conservation under the Clean Water Act) have not yet adopted criteria to evaluate wetlands quality and function, including water quality roles (123).

MCLs developed by EPA for use as drinking water quality criteria, are often used as the benchmark for evaluating surface water quality. Overall, however, the effects of chronic, low-level exposure to agrichemicals on human health[11] and on wildlife have not been fully determined. The National Cancer Institute and other organizations have reported correlations between significant exposure to certain pesticides and cancer in humans (7,58). The relationship between elevated nitrate levels in drinking water and methemoglobinemia ("blue baby syndrome") has been clearly established (47). The risk of cancer from exposure to nitrate has been less well-defined (11), although it has been shown that N-nitroso compounds—many of which cause cancer in laboratory animals—are produced in the human digestive tracts of people who ingest water-borne nitrate (56). The evidence, although incomplete, also suggests that low-level, continuous exposure to nutrients and pesticides can harm aquatic plants and wildlife (10,64).

The adoption of so-called best management practices (BMPs) can reduce nitrate and pesticides in surface water that degrade the quality of drinking water and negatively affect wildlife that use water resources. Technologies to reduce manure, sediment, and chemical runoff have led to sometimes dramatic improvements in surface water quality, as case studies in several states show (87). However, widespread adoption of BMP's may not produce rapid improvements in environmental quality because interactions among soils, surface water, and groundwater may be difficult to manage with BMP's alone. For example, the quality of the South Platte River in Colorado is strongly influenced by groundwater quality. It is estimated that, even with complete elimination of all nitrogen leaching, nitrate currently held in groundwater might enter the river for the next 25 years (54).

Groundwater Quality

There has been no comprehensive assessment of national groundwater quality, but accumulating evidence from national and state studies is helping to understand agriculture's role. Monitoring has confirmed that nitrate and agricultural pesticides are in groundwater in almost every state. Analyses of hydrologic systems show that soil, surface water quality, and groundwater quality are interlinked (124). Furthermore, the susceptibility of groundwater to agrichemical leaching is marked by significant variability across the nation, but land use plays an important role.

For example, nitrate levels are much more likely to exceed drinking water standards in groundwaters under cropland than under any other land use. Monitoring and analyses of pesticides have not yet revealed their roles in groundwater quality on a comprehensive basis. However, a range of

[11] The range of acute (short-term) and chronic (long-term) health effects that might be investigated could include gastrointestinal or circulatory disorders, cancer, neurotoxicity, immune system dysfunction, genotoxicity, and endocrine disruption. See appendix 4-1 for potential health effects of agricultural chemicals that guide EPA drinking water standards.

USDA, AGRICULTURAL RESEARCH

Numerous state studies show that fertilizer residues and pesticides do leach into aquifers. Hera, USDA researchers test the effects of different tillage practices on pesticide movement to groundwater. Because comprehensive monitoring of national groundwater quality is not performed, overall trends in groundwater quality are unknown, and the extent of groundwater degradation due to agriculture is uncertain.

pesticide concentrations have been found under cropland by individual studies, some in excess of drinking water standards.

Evidence that agricultural pesticides and nutrients were reaching aquifers began to accumulate in the . 1970s (box 4-2). By 1990, at least 46 pesticides had been detected in groundwater in 26 states, and nitrate contamination had become more prevalent (86,93). EPA's review of groundwater studies conducted from 1971 to 1991 in 45 states revealed that 132 pesticides or their breakdown products had been found. Of the 23 compounds detected most often, virtually all were associated with agriculture (118). More recently, of 44 states that submitted reports to EPA in 1992 declaring that agriculture was a source of groundwater contamination, approximately one-third ranked agricultural activity as the source of "highest priority" contaminants (120).

EPA's National Survey of Pesticides in Drinking Water Wells (NPS) (117), which randomly sampled drinking water wells across the country, found detectable nitrate levels in 52 percent of community wells and in 57 percent of rural domestic wells. Less than 3 percent of detections exceeded the MCL for nitrate. Detectable pesticide residues were found in 10 percent of community wells and 4 percent of rural domestic wells. Fewer than 1 percent of wells exceeded MCLs for pesticides. From these results, EPA concluded that groundwater quality was a local or regional rather than national issue.

By contrast, groundwater studies conducted in 45 states, compiled as part of EPA's Pesticides in Groundwater Database (PGWDB), focused on areas of intensive pesticide use (1 18). Historically, the majority of such sampling has been targeted to agricultural, rather than nonagricultural areas. As a consequence of this sampling strategy, the PGWDB reported a greater number of wells in violation of pesticide MCLS than did the NPS. Indeed, in its interpretation of the data, EPA cautioned that these high pesticide concentrations probably do not mirror statewide conditions because most studies sampled heavily in agricultural areas where pesticides are used extensively. For example, 11 percent of California wells and 27 percent of New York wells sampled between 1971 and 1991 contained pesticides in excess of federal drinking water standards or MCLs (118). Even though agriculture is not the only source of pesticides in groundwater, many of the pesticides found most often in state studies are used in agricultural production. These partial studies suggest that agricultural areas may be at greater risk to groundwater contamination from pesticides.

Studies conducted by USGS confirm that high nitrate concentrations are often found in aquifers under agricultural areas (59). Nitrate levels in excess of federal drinking water standards have been detected in many aquifers. For example, along the South Platter River in Colorado, groundwater nitrate levels have exceeded MCLs for 20 years, leading to impairment and, in some cases, abandonment, of public drinking water wells (54). In the Lower Susquehanna area of Pennsylvania, all 38 wells with nitrate concentrations higher than the MCL were located in agricultural areas (54). In

BOX 4-2: Agrichemicals in Groundwater Detection: Selected Cases

- Nitrate levels increased between 1974 and 1984 in the Central Platte River Valley, Nebraska (30)
- In California, the nematocide DBCP was found in more than 2,000 wells in the San Joaquin valley and was known to have contaminated groundwater for 7,000 square miles. Between the late 1970s and mid-1980s, more than 50 pesticides were found in the groundwater of 23 California counties (45).[1]
- Several pesticides associated with potato crops, Including aldicarb, were confirmed in the groundwater underlying Suffolk County, Long Island, in 1979-80 (45) [2]
- Between 1982 and 1983, state officials in Wisconsin detected 12 pesticides in the state's groundwater,[3] and developed a monitoring priority list of 45 pesticides determined to be most susceptible to leaching (45)
- In Florida, extensive and highly concentrated presence of aldicarb and EDB, and Isolated, low-concentration cases of silvex and lindane in state groundwater were confirmed in 1982-83 (45).
- Pesticide residues have been detected in 33 percent of over 700 wells tested in Iowa and 39 percent of over 500 wells in Minnesota (1 30).
- In 1985, 84 of more than 430 National Wildlife Refuges were threatened by groundwater and surface water contaminants, 35 from agricultural causes (1 30).
- Between 1986 and 1988, elevated concentrations of nitrate, atrazine, and Indicator minerals related to agricultural activities were detected on the Delmarva Peninsula of Delaware, Maryland, and Virginia (41)

[1] The presence of a host of agricultural pesticides were confirmed through monitoring, a partial list includes 1,2-dibromethane (EDB), 1,2-/1,3-dichloropropane (D-D), simazine, atrazine, carbofuran, DDT and its associates, 2-4-D,Endosulfan, Dinoseb (DNBP) and lindane---all in more limited cases and/or at much lower concentrations than DBCP (45).

[2] aldicarb, carbofuran, chlorothalomil, dacthal, dinoseb, oxamyl, D-D, EDB

[3] alachlor, metolachlor, aldicarb, dinoseb, atrazine, butylate, eptam, cyanizine, carbofuran, chloramben, DCPA, and metribuzin. Most detects were for aldicarb, followed by atrazine, alachlor, and metoachlor.

a regional study of 12 Midwestern states,[12] Kolpin et al. (51) found that 29 percent of samples contained elevated nitrate levels and 6 percent were equal to or greater than the MCL. Sampling at 12,000 sites revealed that groundwater under agricultural croplands exceeds EPA drinking water standards (MCLs) for nitrate 16 percent of the time versus 6 percent or less for groundwater under land in other uses (59).

Efforts have been made to determine what conditions lower or raise the potential for contaminants to leach into underground aquifers in different regions of the country. Mueller et al. (59) noted that groundwater in certain agricultural regions—parts of the Northeast, Midwest, and West Coast—are more vulnerable to nitrate leaching because the soil in these areas does not hold water and nutrients easily, and because fertilizers and irrigation are used more extensively in these regions than elsewhere. In general, shallow aquifers (within 100 to 150 feet of the land surface) are most susceptible to nutrient leaching. Kellogg et al. (49) estimated that the areas where groundwater was most vulnerable to pesticide leaching were the Corn Belt, Southeast, and Lake states. Groundwater in the Northern and Southern Plains, they posited, might be most vulnerable to nitrate leaching.

The actual pattern of groundwater contamination may be somewhat more variable than vulnerability models predict because of the diversity within and among watersheds of a given region. For example, even though fertilizers are used extensively in the Corn Belt, little nitrate appears in the region's groundwater—which suggests that a subsurface geological barrier that prevents

[12] Illinois, Indiana, Iowa, Kansas, Michigan, Minnesota, Missouri, Nebraska, North Dakota, Ohio, South Dakota, and Wisconsin.

agrichemicals from leaching into groundwater exists in the region (49,59). However, other areas of the Midwest, including Iowa and Wisconsin, have different soils and geology, and the groundwater in them is highly vulnerable to leaching of atrazine, other pesticides, and nitrate. Mueller et al. (59) note that in areas where they cannot infiltrate groundwater, agrichemicals may be diverted to surface waters in runoff rather than fully used by crops, held in the soil, or degraded. A notable exception to this pattern occurs in the Southeast, where both surface water and groundwater show very little leaching of agrichemicals. A combination of poorly drained soils, interspersal of agricultural land with forests and wetlands, and high levels of soil organic matter that sequester chemicals and accelerate their degradation may be the reason (54).

Increasingly, states have used fertilizer reduction programs or restricted the use of leaching pesticides in efforts to help clean up groundwater that clearly exceeds state or EPA drinking water standards. However, these state efforts demonstrate the difficulty of getting agricultural contaminants out of groundwater. On Long Island, researchers expected aldicarb residues in aquifers to decompose according to a half-life of three years. However, aldicarb proved to be stable in aquifers, and it is now predicted that aldicarb levels will exceed the state safety guideline of 7 ppb for decades (45). Similarly, although a rigorous program of nitrate management in the Central Platte of Nebraska has resulted in measurable improvement in local groundwater nitrate levels, land use changes alone are unlikely to reduce nitrate levels to drinking water standards within the lifetimes of those currently farming because of the long residence time of groundwater in aquifers.

Changes in how land is used may not be enough to improve groundwater quality, because chemicals that degrade quickly in soil are often much more stable in chemical conditions that are typical of aquifers. Technological reinforcement of land use changes may not be sufficient to reverse contamination, either. A 1994 report by the National Research Council (NRC) noted that it may be impossible to remove agricultural contaminants from groundwater with current clean-up technologies. Even when it is feasible, remediation remains very complex and potentially ineffective while well replacement is often prohibitively costly (66). Because approximately 50 percent of all U.S. residents and at least 95 percent of rural residents (a total of 130 million people) get their drinking water from groundwater aquifers (59), the potential risk associated with groundwater quality problems could be widespread.

Wildlife Habitat

Because U.S. agriculture covers such a vast land area—as much as one-half of the nation's coterminous land base—its effects on the quantity and quality of habitat and on the rate of species disappearance are the subject of some concern.[13] Available research suggests that patterns of agricultural land use, the degree of diversity in crops and animals produced, and the amount and kinds of chemicals used largely determine how agriculture affects wildlife habitat both on and off the farm. Field studies show that trends over the last decades—especially in areas where crops are cultivated intensively—have reduced both the quantity and quality of regional natural habitat. At the national level, agricultural development is the most frequent cause of habitat alteration or loss and the most prominent reason for endangerment among all species, especially mammals and amphibians (32). Grazing is also a significant cause of endangerment, particularly affecting plants in certain regions (32). In total, the status of more

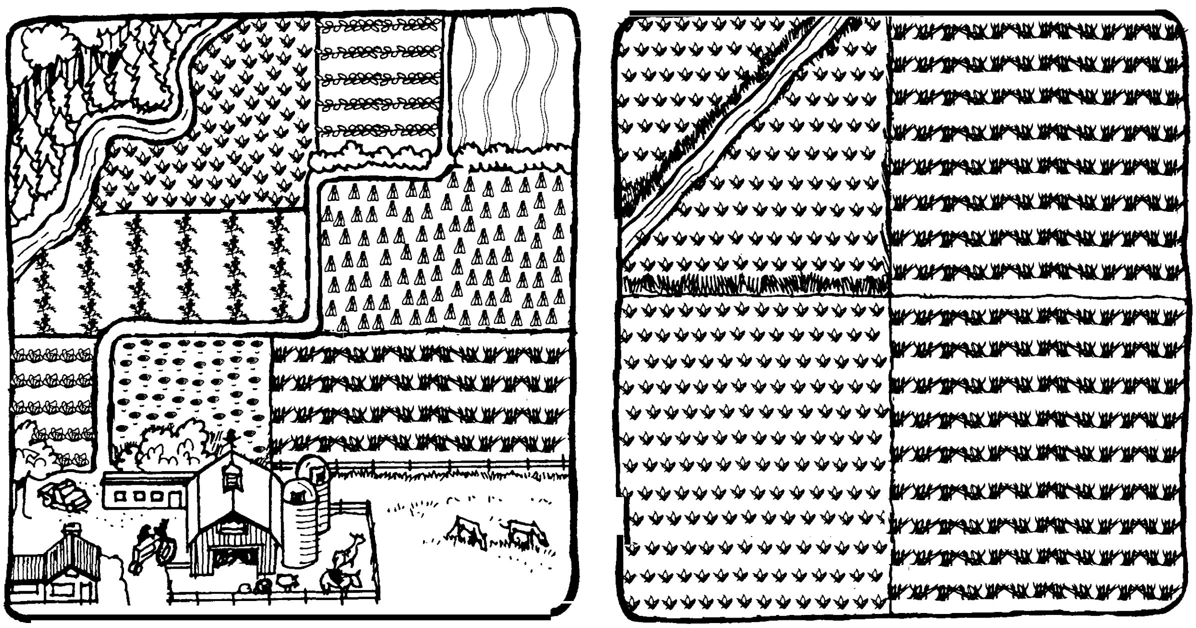
[13] Some scientists estimate that at the present, extremely rapid rate of species loss, two-thirds of all living species, worldwide, could be extinct by the end of the next century (73). This has promoted interest in evaluating the status of species in the United States.

than one-third of all species listed as threatened or endangered has been linked to agriculture. 14

Land (terrestrial) habitats are eliminated, degraded, or fragmented when forests are cleared, wetlands are drained, and grasslands are cultivated. New kinds of vegetation may be established in place of native species. While some wildlife species are attracted to and thrive in the highly modified, frequently fragmented habitats that result, others are not. The range of the red fox, for example, expanded westward as a result of agricultural development. For ground nesting birds, on the other hand, which require large tracts of grasslands, islands of nesting cover interspersed with cropland have increased their exposure to predators (3,125).

Once land has been allocated to farming, the types of practices put in place can either enhance or further reduce the compatibility between production and habitat protection. Agricultural land use trends dominated by large, contiguous fields; cultivation of only one or two crops; and elimination of native tree stands, grassland corridors, and long-term nesting cover play a key role in reducing the amount of terrestrial habitat for many birds, mammals, insects, and plants (figure 4-2). Miles of water (aquatic) habitat are reduced, and the remaining habitat degraded, by straightening

FIGURE 4-2: Dynamics between Trends in Land Use and Wildife Habitat in Agricultural Areas



Over the last four decades, farm fields have gotten bigger, crop diversity has declined, mixed crop/livestock farms are less common, natural stream flows have been altered, native plants have been removed from field edges and stream banks, and mechanical and chemical inputs have intensified While some wildlife have thrived in the new farm landscapes, many have declined.

SOURCE: Office of Technology Assessment, 1995 Assistance provided by Dale Crawford, National Biological Service, Fort Collins, Colorado.

[14] In 1989,45 percent of federally listed Endangered and Threatened species were associated with some form of agriculture (113). In 1994, 38 percent of species listings were related to agriculture (32). The decline in percent does not necessarily infer improvement. as the number of listed species has increased. Also, these statistics were developed separately, not as part of continuous study.

streams (channelization) to support field drainage and irrigation. Nearly 22,000 miles of streams in Minnesota have been lost due to channelization (70). Eliminating vegetation from stream banks or altering in-stream water flows (through flood control, for example) can further reduce the quality of aquatic habitats. The result of these trends has been a reduction in species abundance and diversity, particularly in certain regions (3 1,70,1 25).

Studies of avian populations east of the Mississippi River found that the total number of bird species has declined as forests have been converted into intensive cropland. Moreover, among the species that remain in the cropland setting, the populations of some birds—such as red-winged blackbirds and house sparrows-have increased while the populations of other birds that were once dominant have declined (9).

In the eastern Great Plains region and upper Midwest, the conversion of 30 to 99.9 percent of native prairie, much of it to intensive crop production, represents the largest reduction of any North American ecosystem (78). This conversion has caused sharp declines in the populations of many wildlife species that have historically depended on that habitat, and grassland birds are declining faster than any other group of species in North America (78). At least 55 grassland species in the United States are listed as threatened or endangered, 728 more may soon be listed, and several species indigenous to the Great Plains such as the Audubon bighorn sheep and plains wolf are now extinct (78).

Trends in certain ("keystone") species may indicate the viability of other species that are dependent on them for habitat or food. As an example, the loss of 98 percent of the prairie dog population in the Great Plains has been correlated to declines in the populations of dependent species, including the black-footed ferret, swift fox, ferruginous hawk, and mountain plover (55,78). Similarly, the populations of "indicator species," used to assess farmland habitat quality for all nongame species in 14 Midwestern states, declined significantly (24 to 96 percent) between the 1950s and late 1970s (31). However, because crop cultivation promotes the increase of certain "edge" species like rabbits. white-tailed deer, robins, and cowbirds, underlying changes in species abundance and diversity brought about by agricultural development may not be obvious to the casual observer.

Because they are inherently more complex than cropland and generally involve less intensive cultivation, rangeland regimes in the West and Southwest can be relatively more compatible with native habitat uses. However, technologies for maintaining native grasses on semiarid and arid rangelands are lacking, and the introduction of non-indigenous plant species to improve grazing conditions or to control pests has caused critical declines in animals, insects, and plants that are unique to these areas (77,95). Grazing in riparian areas, especially in the Southwest, California and the Northwest, has increased sedimentation in some streams, covering spawning sites, clogging fish gills, and elevating water temperature.

Since the 1970s, appreciation for the unique function of wetlands as wildlife habitat has grown. As a specialized form of surface water, wetlands provide seasonal or permanent habitats for one-third of the nation's endangered and threatened species and sustain 75 percent of commercially landed fish and shellfish (42,92). The

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The prairie pothole region of the Great Plains remains a unique example of natural wetland/grassland habitat in an intensive agricultural region. An important hub of the Central Flyway used by migratory birds, the pothole region is also the breeding ground for more than half of all ducks native to North America.

Prairie Pothole Region, about one-fourth of which lies in the Dakotas, produces 50 percent of North America's duck population (112). Prairie pothole ecosystems also provide habitat for mammals, such as deer, mink, and fox, and are thought to play a critical role in maintaining plant diversity (112). Wetland losses due to agricultural conversion have declined considerably since the 1950s, and an increasing number of farmers are exploring the potential for compatibility between cultivating crops and restoring wetlands on suitable parts of their fields.

The extent to which normal use of agricultural chemicals affects wildlife species is not fully understood, but a range of direct and indirect effects on terrestrial species have been documented (33). EPA estimated that in the 1980s, one to two million birds died every year from exposure to the pesticide carbofuran (113). The U.S. Fish and Wildlife Service (FWS) determined that nearly 20 percent of species that became endangered or threatened in 1988 had been adversely affected by pesticides (113). Pesticides can reduce insects that provide food for birds and other animals, an effect that is associated with declining populations of the bobwhite quail (3).

As noted previously, aquatic life can be harmed by nutrients carried in runoff to surface waters. Eutrophication reduces dissolved oxygen and may release toxins into the aquatic habitat. In addition, herbicides in the aquatic environment can diminish the food supply for fish and other herbivores. Chronic, low-level concentrations of both herbicides and insecticides in surface water have been linked to reproductive failure and developmental abnormalities in fish and other aquatic organisms (10,64). Some pesticides that become concentrated in animal tissue ("bioaccumulate") as they move through the food chain to predatory birds and mammals may have long-ranging and pervasive negative effects on both aquatic and terrestrial habitat quality, and particularly on sensitive species (10).

Changes in some farming practices and field patterns can reverse the decline of many species and enhance wildlife habitat both on and off the farm. Multi-cropping systems increase diversity of habitat structure and species richness (31,78). Field patterns that minimize fragmentation of habitat areas or that intentionally link habitat areas through landscape corridors can greatly benefit wildlife. Wetlands are being restored on farms in several states. Land set-asides, such as those created by the Conservation Reserve Program (CRP), can improve long-term grassland cover. Declining populations of pheasants, migratory waterfowl, and grassland birds have made dramatic reversals on lands (48,61). Changes in irrigation water use are also being used to enhance aquatic habitat (box 4-3).

Innovative applications of agricultural technologies may also make farming more compatible with wildlife habitats. In California, post-harvest flooding and cage-rolling of rice straw is providing seasonal wetlands for migratory waterbirds. This innovation is an alternative to rice straw burning, which will be banned by the year 2000 (27). Some farmers are exploring the relationship between various commodity crop mixes and bird habitats (111). Various techniques to reduce agrichemical use, create riparian buffers to keep runoff out of surface waters, and plant grassland edges alongside fields (to provide habitat) are being investigated. Such technologies, used in tandem with new land use patterns, point to cases in which it may be possible to enhance both agricultural productivity and wildlife habitat.

Soil Quality and Soil Erosion

The rate of soil erosion is often used as a benchmark of soil quality, but it is only one indicator. The term "soil quality" covers physical, chemical, and biological elements, including microbial density, organic content, electrical conductivity, acidity, structure, chemical contamination, and infiltration rate, in addition to smell, color, and texture (26). Soil quality can also be assessed in terms of the soil's capacity to perform productive and environmental roles. In this regard, there are three key indicators of soil quality:

- productive capacity (the capacity to promote the growth of plants);

BOX 4-3: California's Central Valley Improvement Project to Restore Habitat

In response to Increased pressure to safeguard the environment, the federal government and the California State Water Resources Board have taken actions in a prime agricultural area to protect water for fish and wildlife (126) Under the new federal law (P.L. 102-575), about 15 percent of the Bureau of Reclamation's Central Valley Project water normally available to agriculture is reserved for flow requirements for fish and wildlife propagation and restoration, During years of normal precipitation, this reservation level would not significantly affect agriculture However, in years of low precipitation, water available to farms would be reduced accordingly, In effect, the project's drought buffer goes to fish and wildlife rather than to farmers

The California State Water Resources Board actions were taken to improve water quality in the Sacramento-San Joaquin Delta Estuary They include measures to make more water available during fish migrations and fees on irrigation districts to finance wildlife habitat and urban conservation measures What are the possible implications for California's lucrative agricultural trade sector if the scheme is fully Implemented? According to a study by the U.S. International Trade Commission, agricultural production and exports will not decrease significantly in the long term, but the composition of those exports will change to include more crops such as fruits and vegetables, and/or crops that use less water (1 26) On December 15, 1995, the state of California and the federal government signed an agreement resolving the particular elements of how to Implement the new law—a complicated process because multiple environmental statutes and several political jurisdictions were involved.

The final details will be worked out by state and local officials, but it appears that farmers will face the greatest annual costs, and cities will have less water in dry years, while commercial and recreational Interests stand to gain (20) The process of reaching a consensus water quality plan involving multiple, fractious parties with large stakes at risk was considered a future model for such negotiations.

SOURCE: Office of Technology Assessment, 1995

- ecosystemic function (the ability to regulate infiltration and surface movement of water within a watershed); and
- environmental function (the ability to act as a buffer for water and air quality by sequestering and degrading carbon, agricultural chemicals, and organic wastes).

Despite the intuitive appeal of the soil quality concept, it remains immature and therefore comprehensive data or assessments are not at hand (64).

Soil erosion is only one element of the broader soil quality concept, but it is the only element with extensive data. Despite some questions about the reliability of historical data,[15] national estimates reveal that aggregate cropland erosion has declined significantly over the past four decades. The average water erosion rate has fallen approximately 50 percent, from six to about three tons per acre, and the wind erosion rate has declined about one-third, from about nine to six tons per acre between 1945 and 1992 (50). Between 1982 and 1992, National Resources Inventory (NRI) data show decreases in water and wind erosion of 22 percent on cultivated land (71). Reduced erosion on all U.S. cropland saved nearly one billion tons of soil in the past decade (25).

Marked differences in soil erosion are apparent when data are examined regionally. Between 1982 and 1992, erosion declined the most in the Northern Plains (31.7 percent), followed by the Mid-

[15] The accuracy of erosion control statistics is complicated by different sampling and measurement methods. Data are marginally more consistent than they were when the National Resources Inventory was instituted in 1977, but comparisons overtime should be made cautiously.

Soil quality depends on more than the rate of erosion. Color texture, organic content, electrical conductivity microbial populations, acidity porosity and concentration of toxic substances are some of the many other characteristics that determine the quality of soil.

west (21 percent), Southern Plains (14.8 percent), and the Mountain region (7.4 percent) (25). Water and wind erosion patterns varied within those regions, depending on which crops were planted. For instance, soil erosion due to water increased on all cultivated land in the Southern Plains, on soybean acreage in the Northern Plains, and on cotton acreage in the Mountain region. Soil erosion due to wind increased on wheat and soybean acreage in the Midwest, and on wheat acreage in the Mountain region (25). Furthermore, the 1992 NRI data reveal substantial variation in soil erosion trends within regions (50).

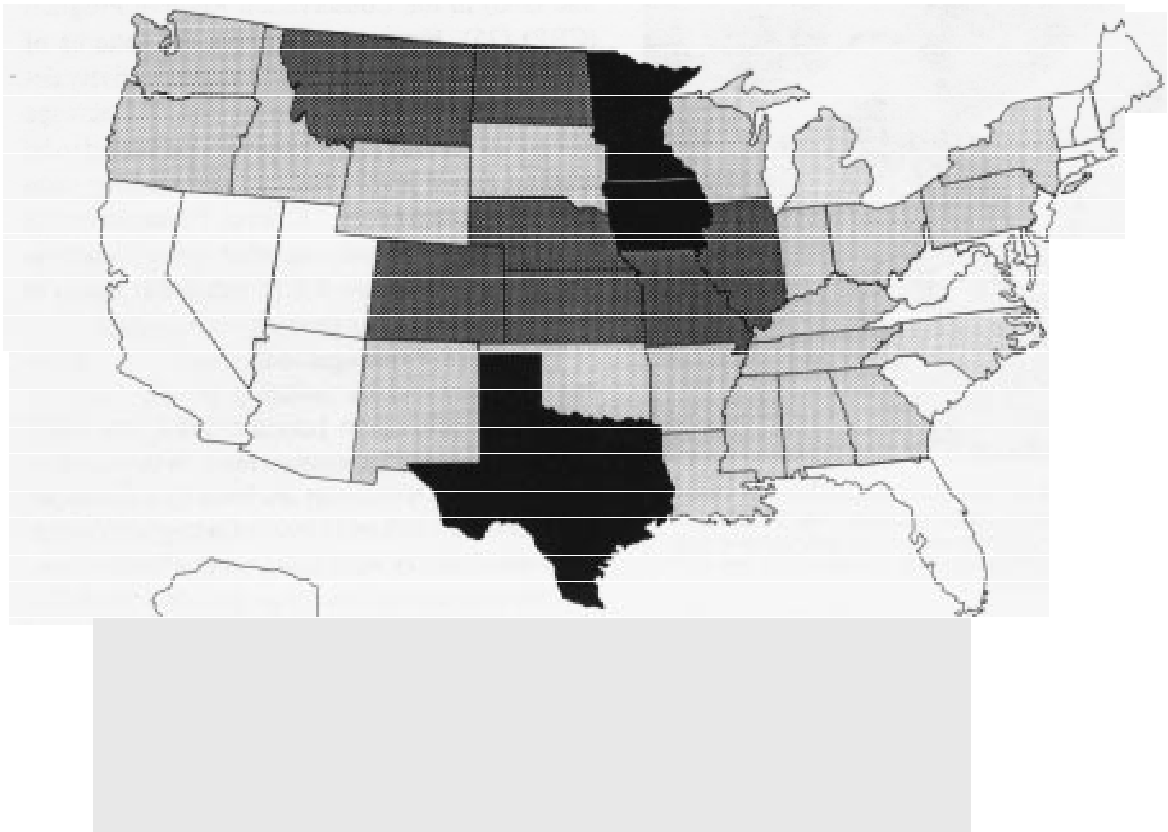
Even though these statistics suggest overall improvement, they do not describe remaining erosion problems, and do not distinguish the influence of management from lands of varying erodibility moving into and out of production (71). Indeed, the most recent aggregate declines in erosion may heavily reflect the idling of acres (more than one-third of the country's most erodible land) in the Conservation Reserve Program (CRP) (25). Figure 4-3 portrays the patterns of cropland vulnerable to long-term productivity declines due to water and wind erosion. The acreage categories include those croplands estimated to be eroding above levels that can sustain long-term productivity, termed the "T" level, [16] plus the highly erodible lands currently enrolled in the Conservation Reserve Program (CRP) that could return to crop production after their contracts expire.

The effect of management changes on erosion can be estimated by isolating acreage that remained in cultivation between 1982 and 1992. NRI data suggest that erosion rates on land continuously planted with crops declined by 1.6 tons per acre between 1982 and 1992, a finding which suggests that farmers were using more effective conservation practices over that decade (25,64,71).

A shift in technology away from "clean-tilling" and toward crop residue management has been a key factor in reducing both soil and water runoff from fields. While reduced tillage may not yield environmental benefits under all conditions, studies indicate that it generally improves soil and surface water quality Its effects on groundwater and wildlife are not fully understood.

[16] The tolerance, or "T," level is set by the SCS and approximates the maximum target erosion level above which unacceptable on-site degradation is believed to occur. The accuracy and usefulness of T levels is somewhat controversial.

FIGURE 4-3: U.S. Cropland Vulnerable to Long-term Productivity Declines Due to Erosion



The severity of soil erosion depends on a combination of inherent soil characteristics, climatic factors, and land management. The number of acres now eroding over the level that leads to long-term productivity losses, the "T" level, plus the number of CRP acres with the potential to erode at a rate over T if returned to crop production, comprisas the total vulnerability of U.S. cropland to erosion-mduced declines in productivity

SOURCE: OTA, 1995. Compiled from data provided by Tim Osborn, Agricultural Economist, USDA/ERS, personal communication, 1995; J. Jeffrey Goebal, "Estimated Average Annual Sheet and Rill and Wind Erosion In Relation to T-Value of 1992 Cropland," US. Department of Agriculture, Natural Resources Conservation Service, 1995.

Although farmers used conservation tillage more during the past decade,[17] they may also have engaged in more contouring and strip cropping, constructed terraces and grass waterways to control erosion, and shifted their crop rotations.

Rangelands pose special soil quality problems. Box (8) suggests that rangeland productivity on private and public lands has generally improved since the Taylor Grazing Act of 1934. In 1982, more than 33 percent of rangelands were judged to

[17] Box 2-1 of Chapter 2 defines conservation tillage. Dicks (25) notes that between 1983 and 1991, the acreage under no-till management increased from 8.6 million (2 percent of the total crop base) to 24 million; however, no correlation has been made between the option of no-till and highly erodible land. He suggests that although conservation tillage by definition should produce conservation gains, conservation is likely not the most important inducement for adoption. Pierce and Nowak (71) conclude from analysis of 1992 NRI data that conaervation tillage acreage declined between 1982 and 1992, and that adoption is not highly correlated with the most highly erodible acres. These findings conflict with official USDA estimates reported in chapter 2, but an explanation for the conflict is lacking.

be in "excellent or good condition" (22). However, the 1982 and 1987 NRI showed that 19 percent of acreage (76 million acres) eroded over the "T" level (22,109). The 1992 NRI shows that rangelands suffer from higher wind erosion rates than land used for other purposes, and that few improvements have been observed since 1982 (25). Ruyle (77) notes that rangelands are inherently vulnerable to erosion, and explains that poor management can exacerbate the problem.

Erosion indicators are mostly measures of soil quantity and cannot convey comprehensive soil quality conditions. But historical trends in erosion may suggest the changes in overall soil management which, in turn, influence soil quality (64). The level of correlation between erosion trends and soil quality remains unclear. Moreover, conservation practices designed to reduce erosion may or may not improve overall environmental quality. Conservation tillage is a prominent example. Conservation tillage changes the biological, physical, and chemical properties of soil, but the balance between benefits and risks is not totally predictable. In field studies, conservation tillage has been linked to beneficial sequestering of carbon in the upper layer of soil, which helps prevent loss of ozone-depleting gases; to improving wildlife habitat by reducing mechanical disturbance of ground nesting sites; to retention of bulk organic matter, which aids water retention and infiltration as well as promotes microbial life; and to reduced erosion and water runoff. The long-term environmental effects of conservation tillage are still under investigation. Some conclude it will ". . . contribute to a net decrease in total potential water quality degradation (104)." However, there is conflicting evidence on the effects of conservation tillage on groundwater quality (28,40). Perhaps the most important result of studies to date is that the benefits associated with conservation tillage have not occurred universally. As with all technologies, its applicability varies depending on site-specific hydrogeological and soil characteristics, cultivation practices, and the management skills of the farm producer. Several initiatives are under way to develop techniques for evaluation that may allow farmers to directly gauge the impacts of their farming practices on soil quality.

Strengthening Agroenvironmental Science

There is a vast difference between the percentages of USDA research monies devoted to increasing agricultural production (historically more than 60 percent) and addressing environmental issues related to agriculture (historically about 10 percent). This relative lack of federal support for agroenvironmental research will limit the quality of information available to university scientists, extension agents, federal and state program managers, agribusiness, farm consultants, farmers, and environmentalists. Knowledge of unique regional agricultural, socioeconomic, and environmental characteristics is also critical to devising effective policies—both in terms of production and environmental enhancement—in agricultural regions. Incomplete information may lead to agroenvironmental policies that are poorly targeted and unnecessarily costly to the private and public sectors.

Expanded monitoring alone is unlikely to fill the gaps in knowledge, because the nature of many agricultural interactions with environmental resources remains poorly understood. (See box 4-4.) Indeed, more monitoring without better science to guide the monitoring will likely be inefficient. As noted above, the significance of many agrichemicals for water or soil quality and, consequently, for biological health, is still under investigation, and the significance of habitat modification and destruction brought about by intensive cultivation remains a topic of debate. The role of agriculture in the functioning of specialized or rare ecosystems, such as wetlands, has not been extensively examined. The need, then, is not just for more research, but for more sophisticated agroenvironmental science. Three areas in particular (derived from the analyses of this chapter and corroborated by recommendations of the National Academy of Sciences (64,65) must be explored: the functioning of environmental and farming systems and their interrelationships, the spatial environmental conditions that flow from these rela-

BOX 4-4: Who Answers Key Scientific Questions on Water Quality?

Water resources—surface water and groundwater—have been studied for decades, and yet national trends in the condition of this important resource have never been evaluated systematically. At the state level, water quality assessments are performed every two years (as stipulated by the Clean Water Act (CWA), but they do not represent a coherent strategy to monitor the conditions and implications of national water quality. As a result of current research and monitoring, questions remain about the extent of agricultural contamination and about its significance for aquatic habitat, for the availability of safe drinking water, for agricultural production, and for recreation. As noted in this chapter, water safety standards adopted by the EPA reflect that the implications of poor water quality remain only partially known. What don't we know about water quality? Why don't we know? Who should be asking researchers to fill in the missing answers?

Researchers have found that agricultural herbicides, insecticides, and nitrogen fertilizer residues are prevalent in rivers, streams, lakes and reservoirs in regions where they are used. Furthermore, some of these agricultural chemicals, notably herbicides, have been found to degrade more slowly in water than they do in soil. This stability in water, combined with the natural movement and linkages among surface waters and between surface water and groundwater, result in the capability of agricultural pollutants to migrate great distances, affecting water quality hundreds of miles from their point of origin. Such findings raise a number of questions for agricultural producers, consumers and policymakers:

- How long do agrichemicals remain in regional surface waters and at what *concentrations?*
- What conditions affect the speed at which these chemicals degrade? Can technology help?
- How far can agrichemicals go in water systems? Are they ultimately stored, degraded, or transported indefinitely?
- Do commonly found levels of agrichemicals affect the ability of water to support plants and wildlife?
- How many people, nationwide, are exposed to agrichemicals in excess of safe drinking water levels?
- What effects on human health can emerge from regularly swimming in or drinking low-dosage mixtures of many herbicides, Insecticides, and fertilizer residues?

While some of these questions have been asked in some studies, a focus on the links between water systems, conditions, and implications has not been emphasized in most large-scale studies of water quality. A research agenda that focuses on conditions without supplying a context of understanding for environmental or health implications makes it very difficult for such research to be meaningful in the policy process. By the same token, a policy agenda that remains disengaged from the research agenda Increases the risks that relevant questions will remain unanswered.

The best example of the inadequacies of current research and monitoring of the nation's water resources may be state water quality reports submitted to EPA under section 305(b) of the CWA. These data form the basis of EPA's biannual Water Quality Inventory report submitted to Congress, they are frequently cited in research reports about national water quality; and they remain the most comprehensive national monitoring effort to date. Because of the way studies are conducted, however, they may not accurately reflect national trends. For instance, 305(b) evaluations only include a fraction of riverways, lakes, estuaries and coastlines (see table 4-1), but the evaluations performed need not represent a scientific sample. From year to year, and state to state, evaluations are not required to follow consistent protocols or result in trend information. Thus, the CWA process has produced 20 years of data that add up to an incomplete and even incompatible set of answers.

SOURCE Off Ice of Technology Assessment, 1995 tionships, and the dynamic implications of these conditions for environmental health.

Analyses have underscored the importance of understanding how agricultural systems interact with environmental systems (64,93). An agroecosystem approach parallels a shift in emphasis from on-farm, on-site environmental concerns to linking on-site practices with off-site conditions and, indeed, with the total agroenvironmental system. The fundamental research questions are not whether interaction between agricultural and environmental systems occurs, but how it occurs.

The geographical diversity of environmental conditions and regional variations in agricultural production make a better understanding of geospatial relationships crucial. Inadequate spatial information precludes better targeting of program responses. For example, as Mueller et al. (59) and Smith et al. (83) illustrate in their research, effective targeting of water quality policies would entail: a good understanding of regional vulnerability to agrichemical leaching and sediment erosion, and monitoring data that describe actual water quality conditions.

A critical dimension of farm and environmental systems is the way they interact over time. These long-term dynamics provide a link to understanding long-term implications for agroenvironmental health. The stress, response, adaptation, and recovery or extinction processes that are integral to ecological resources take place often over long periods of time, as mentioned with groundwater pollution and rehabilitation.

Many traditional soil and water conservation programs have been implemented over past decades without precise understanding of these systems, conditions, and environmental implications. However, as population and production pressures places more stress on environmental resources, it is not at all clear that general guidance can suffice. The diffuse and diverse nature of agricultural runoff, which has impeded progress on nonpoint water pollution for 20 years, is unlikely to be resolved without much more sophisticated understanding of the problem than currently exists. In particular, such problems require more sophisticated science than past efforts to help develop programs that meet environmental goals while maintaining farm profits and U.S. competitiveness in international agricultural markets.

FEDERAL CONSERVATION AND ENVIRONMENTAL PROGRAMS

Since the early 1970s, public pressure has progressively expanded the mandate of both traditional farm legislation and general environmental laws to go beyond boosting agricultural productivity to promoting environmental health. As programs to manage the environmental side effects of agricultural practices have expanded, traditional soil and water conservation programs have declined, relatively speaking. These developments reflected a growing recognition of farmings' effects on environmental quality not captured by market prices, and rising concern about the long-term sustainability of production (17).

Depending on the definition of a program, there are at least 35 separate USDA programs for conservation and environmental purposes, including about 12 for research and data gathering (appendix 4-2). At least another 20 are administered by other agencies, including EPA, the Department of Interior, the U.S. Army Corps of Engineers, and the National Oceanic and Atmospheric Agency (appendix 4-2). Estimated public expenditures for all programs are $6.5 billion for 1995 (104).

The large number of programs raises questions of overlap, conflict, coordination, and mixed incentives to farmers and ranchers, but a comprehensive program analysis has not been conducted, even within USDA. Opportunities for reconfiguring and targeting the programs—to clarify the signals and incentives they give to farmers, agribusiness, legislators, and environmentalists and to save budget expense—may exist. Possible policy options for restructuring program approaches are explored in the last chapter. Diagnosing the nature of private incentives to adopt agroenvironmental practices is a key principle to be used in any restructuring (5).

Three general types of federal policy approaches to soil conservation, water quality, and wildlife habitat issues are discussed in this section. Voluntary efforts aided by education, technical assistance, and subsidy programs have been the predominant approach to environmental management in agriculture. As illustrations, the dominant soil conservation programs are examined in detail. Environmental compliance schemes, which are integrally linked to farm commodity programs and supply programs, are discussed next, followed by an assessment of regulatory approaches. The objective of the assessment is to review the performance of the three program approaches and identify strengths and weaknesses for application to agriculture's broadening environmental agenda. In the chapter's final section, we discuss the potential of technology research and development aimed specifically at enhancing agriculture's environmental performance while simultaneously maintaining profitability. These "complementary technologies" have not received program emphasis, but hold the potential to bring private incentives into closer correspondence with public environmental objectives.

Voluntary Education, Technical Assistance, and Subsidy Programs

A multitude of past and present USDA conservation and environmental programs are comprised of either voluntary education, technical assistance, and/or subsidy (VETAS) elements. These kinds of programs have historically received more funding, and have a broader scope, than other kinds of conservation and environmental programs.[18] Education and technical assistance and subsidies for conservation practice cost-sharing or for land rental and easement payments have often been operated together. Thus they are examined as one category here. In situations where conservation-oriented technologies do not offer cost savings or other private benefits, education and technical assistance are likely to be ineffective without subsidies.

Estimated annual expenditures for USDA conservation and environmental programs total just under $3.6 billion for 1994, although that figure is projected to fall to about $3.1 billion in 1995 (appendix 4-3). With the primary exception of technical assistance and administration for compliance schemes detailed in the 1985 farm bill, those monies fund VETAS programs. More than 50 percent, almost $1.8 billion of the total, will pay for land that is set aside in 1995 under the CRP, plus the Water Bank and Wetland Reserve programs. Most of these land "rentals" by the government are scheduled to end sometime between 1996 and 2005. The largest share of the remaining $1 billion will pay for technical assistance, extension services, and administration, followed by public works projects such as emergency watershed protection, which helps flood recovery efforts. Less than $100 million is slated to install cost-sharing practices under the Agricultural Con-

[18]The Natural Resources Conservation Service (NRCS), formerly the Soil Conservation Service (SCS), provides farmers with education and technical assistance. Typical education/assistance efforts include laying out erosion control practices such as terraces, and providing information about conservation crop rotations, tillage options, and wildlife habitat. The Extension Service also provides conservation education and technical assistance, sometimes in cooperation with the NRCS and sometimes separately, depending on the state and the project.

Several programs distribute subsidies. The Agricultural Conservation Program (ACP), begun in the 1930s and now operated under the Consolidated Farm Service Agency (CFSA), provides financial assistance in the form of cost-sharing to implement conservation practices. For example, farmers are given a share of the expense of installing terraces (usually 50 percent or more) subject to CFSA eligibility requirements, available funding, technical approval by NRCS, and approval by a local conservation board. Annual ACP payments are limited to $3,500 per farm, which can effectively rule out large-scale projects in any year. Other programs using conservation practice cost-sharing monies include the Great Plains Conservation Program, Emergency Conservation Program, CRP, Wetland Reserve Program (WRP), and the Colorado River Salinity Control Program.

In addition to cost-sharing subsidies, rental and easement payments remove land from production temporarily or attach use restrictions for conservation purposes. The CRP, approved in the 1985 farm bill, has set aside 36.4 million acres to control erosion and for other environmental purposes. The maximum annual rental bill so far has been $1.8 billion. The WRP, though much smaller, protects wetlands through rental and easement payments. Also, the Water Bank Program has rented land near water bodies for habitat and other purposes.

servation Program (ACP) in 1995—a drop of nearly 50 percent from levels during the past decade.

Appendix 4-3 presents the expenditures for each USDA conservation-related program from 1983 to 1995. Although there are at least 35 programs, a large number of them have relatively low funding—a few large programs account for the majority of expenditures. Many programs were authorized at higher levels, but actually received little or no funding. A comprehensive review of all the ETAS programs has not been conducted and is not possible here. Rather, the discussion focuses on the largest program component—soil conservation—and the largest single program within soil conservation—the CRP. These soil conservation programs, especially during the last decade, have also incorporated water quality objectives and affected wildlife habitat.

Soil Conservation Programs

Federal soil conservation programs began in the Great Depression, when farmers faced the combined woes of a collapsing economy, drought, and massive erosion on their land. One program authorized work on soil erosion control as a means to reduce unemployment (72). To overcome legal obstacles to paying income support to farmers for restricting production, soil conservation programs and farm income payments were joined. Both programs have endured. "Despite the 'New Deal' intent of providing emergency relief, the farm commodity programs and the soil conservation programs have continued with few modifications to the present" (4).

Several evaluations have found that soil conservation program expenditures could be redirected and result in greater erosion control (100).[19] In a 1974 study, USDA estimated that cost-sharing used for conservation practices in the Great Plains Conservation Program (GPCP) could help to further reduce wind and water erosion if those subsidies were used for more cost-effective erosion control practices (107). Another USDA study found that lands with erosion rates very near the so-called T level received nearly half of ACP financial assistance (98). By implication, that half of the available program subsidies was not applied to land with severe erosion problems.

Evaluations by the General Accounting Office (GAO) of the technical and financial assistance programs also concluded that improved targeting of program resources could lead to better control of erosion (88,89). In a later evaluation, the SCS found that 40 percent of its technical assistance was applied to lands eroding under the T level (108). In the same study, the SCS determined that the effectiveness of technical assistance was lower in areas targeted for erosion control, which implied that more intensive effort was needed to accomplish erosion goals in those areas.

The 1977 GAO study also found that farms participating in the conservation programs did not achieve erosion rates significantly lower than those on farms that did not participate. A county-level study similarly found that farmers with SCS conservation plans did not achieve significantly greater erosion control than farmers without such plans (29).

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[19]In the midst of these evaluations (1977), Congress passed the Soil and Water Resources Conservation Act (RCA), which directed USDA to collect comprehensive resource data to assess the nature of conservation problems on private lands, evaluate conservation programs, and construct a National Conservation Plan (NCP). The RCA established the National Resources Inventory (NRI), conducted in 1982, 1987, and 1992, which provides critical data for program evaluations and monitoring resource trends (110).

Two principal findings emerge from these and other evaluations. First, soil conservation education, technical assistance, and practice cost-sharing have not been focused on the most severe erosion problems or on delivering the most cost-effective practices. Second, voluntary education and technical assistance alone have not led to significant conservation benefits (60). By their nature, these information programs are most effective if they make operators aware of practices and technologies that offer cost savings or increased returns while simultaneously reducing erosion—the complementary or "win-win" situations. These findings also likely apply to VETAS approaches to water quality and wildlife problems where insufficient targeting has occurred and farmers face major practice costs.

Evaluations also suggest that cost sharing or subsidies are likely the most important determinants in inducing farmers to adopt certain agroenvironmental practices (29,34). If conservation benefits are to be realized in cases where farmers do not have private economic incentives, either subsidies or some form of regulation must be employed. The other, longer term alternative is to develop profitable technologies that can be substituted for currently unprofitable technologies.

In a comprehensive assessment following the studies of the late 1970s and early 1980s, the USDA's Economic Research Service (ERS) performed the first nationwide benefit-cost assessment of the ACP, Conservation Technical Assistance (CTA), and the GPCP (100). Estimated erosion control benefits and reduced offsite damages were compared with costs. A key finding: on average, the estimated benefits exceeded costs only for land eroding at a rate of more than 15 tons per acre. Given that the programs were devoting most of their resources to lands eroding at a rate of less than 10 tons per acre, and nearly half of program resources went to lands eroding at a rate of less than five tons per acre, the study concluded that significant public benefits could be secured by redirecting program resources to the lands that were eroding the most. ERS made five major recommendations for program reform, which have anticipated policy developments to a substantial degree:

1. target erosion control programs,
2. include offsite damage reduction as an erosion control benefit,
3. base conservation incentives on public benefit,
4. estimate erosion control benefits and costs, and
5. improve research and data for program evaluation.

On the heels of these evaluations, and with the benefits of 1977 and 1982 national surveys of natural resource conditions and a National Conservation Plan, the 1985 farm bill authorized three major erosion control programs aimed directly at highly erodible lands. The CRP, a massive effort to retire highly erodible or other environmentally vulnerable land through voluntary 10- or 15-year contracts, was the principal program.

Conservation Reserve Program

Although the achievements of the 1985 farm bill's conservation measures cannot be documented until full implementation and evaluation of all effects, several studies have assessed their preliminary performances. The CRP has been the subject of intense scrutiny because it represents the largest expenditure of conservation funds, nearly $20 billion, and affects nearly 10 percent of U.S. cropland. Preliminary evaluations have arrived at two basic conclusions: the program appears to generate net economic benefits, mostly from environmental improvements, but net governmental costs are positive, implying a drain on the federal treasury.[20] At this writing, a final economic judgment cannot be made, because it is still not possible to measure with precision the full physical and biological effects and the dollar value of environmental benefits.

Regardless of such difficulties, one conclusion of CRP evaluations has been strong and virtually unanimous: the early benefit-cost ratio could have been much higher with better environmental targeting and more effective controls on the payments made to farmers for "renting" their land (67,74). As a result of the 1990 farm bill, USDA changed CRP enrollment procedures to address environmental priorities specified in the farm bill legislation. The changes included a rudimentary targeting scheme as well as a provision to hold rental payments at or below market levels (67).

A regional study of the land enrollment patterns in California, Idaho, Oregon, and Washington shows that the 1990 CRP was more successful in concentrating enrollment of land in highly erodible counties than the 1985 version (129). On average, this change should produce more environmental benefits, but detailed assessments of enrollment patterns within the counties are also necessary. Concern now centers on what will happen to CRP lands after the government stops renting them. Experience with the Soil Bank, an earlier major long-term set-aside program in operation from 1958 to 1972, shows that most (probably two-thirds or more) of the idled land will again be used for producing crops and could trigger another round of environmental problems—which in turn would increase the need for remedial programs.

Conservation and Environmental Compliance Programs

The compliance provisions of the 1985 farm bill represent a departure from traditional agricultural conservation and environmental programs. They were, in fact, considered landmark legislation, because they made farmers adhere to conservation standards in return for their agricultural program benefits, including commodity deficiency payments. The compliance mechanisms were meant to help control erosion on existing cropland (conservation compliance); they were also intended to regulate farmers' efforts to turn grasslands into cropland (Sodbuster), and convert wetlands to cropland (Swampbuster). The Sodbuster and Swampbuster provisions were a tacit recognition

[20] The first comprehensive assessment, conducted midway through CRP enrollment and before the 1988 drought lowered crop surpluses, estimated the potential supply control, food cost, environmental benefits, and other effects of a 45-million acre CRP, as authorized in the 1985 farm bill (128). The preliminary investigation concluded that the CRP would likely produce net economic benefits in the range of about $3.5 billion to $11 billion. However, the study methodology and data were admittedly incomplete concerning such subjects as the effects on consumer food price increases, interaction between government supply control instruments, some environmental benefits, and the likely pattern of enrollment after midway signup. Although its net economic benefits were estimated to be positive, the CRP was projected to cost the federal budget more than it saved in reduced supply control expenses—a range of $2 billion to $6.6 billion over the program's life.

To reflect new developments, an updated CRP assessment was conducted after the effects of the 1988 drought had been felt and more lands had been enrolled in the CRP (102). Although the studies are not strictly comparable, because the methodologies used to estimate production, supply control, and price effects differed, the basic conclusions remained the same. The CRP was estimated to produce net economic benefits in the range of $4.2 billion to $9 billion, but the likely net government cost rose to $6.6 billion to $9.3 billion. Notably, from a net economic perspective, increased farm profits and higher food costs nearly offset each other, and the environmental and timber supply benefits accounted for most of the positive margin. Again, the methodologies for estimating the value of environmental benefits are crude, relying on estimates based on large area projections rather than specific documented effects.

If the projected soil erosion reductions or presumed linkages to environmental resources are not accurate, then the estimated environmental benefits, such as water quality, will not be what they are expected to be. Also, recent survey results indicate that most enrolled acres will likely be used for agriculture again if CRP payments end, and so the expected benefits may be brief (85). Ex post studies of environmental changes resulting from the CRP should be conducted to check the accuracy of estimated effects. For example, a study of changes in stream water quality conditions in southern Illinois, where large amounts of CRP land were enrolled, did not reveal improvements had occurred as anticipated (23). The geographic pattern and timing of benefit streams do affect the program's economic bottom line. Similar assessments should be conducted on timber and wildlife benefits, which account for between about $5 billion and $6 billion of the net benefits. The final benefits and costs of the CRP remain unclear until those assessments are completed.

on the part of legislators that, as traditionally administered, federal commodity program payments likely gave farmers economic incentives for converting grasslands and wetlands to crop production (42,52).

Not surprisingly, the measures have been the subject of controversy since their inception. Farmers worried that meeting the originally proposed conservation standards would cost too much and force them out of the commodity programs, thus denying them price and income supports. The SCS ameliorated that concern by developing the concept of alternative conservation systems (ACSs), which were intended to allow farmers more flexibility in attaining the compliance standards (99). Widespread adoption of conservation tillage systems by many farmers (primarily to save fuel, labor, and machinery costs) often satisfies conservation compliance requirements and appears to have minimized potential economic distress for the overall sector. However, an internal investigation of the application of the ACSs suggests they were used without clear and consistent rationales and have not been documented to achieve compliance erosion control standards (106).

A mid-term external investigation of the conservation compliance measures suggested that the programs were not being implemented in a uniform manner to achieve the standards defined in program regulations (84). Generally, near one-half of the cases in sampled counties did not satisfy the requirements of implementing regulations. The same external field-level evaluation of the Swampbuster provisions indicated that the sanctions did slow the conversion of wetlands to cropland, but were not being uniformly enforced (84). Another evaluation conducted by the USDA's Office of Inspector General, based on a 1991 audit, found a similar rate of noncompliance (105). (The sample size was, however, extremely small.) In contrast, SCS internal status reviews of progress have indicated a small percentage of producers are not in compliance with their plan requirements (103). There is no official explanation available for the different findings of the external reviews and internal status reports. Questions about sampling, different performance criteria and standards, and measurement of plan implementation require answers. Congressional oversight hearings have been held on these issues.

These mixed evaluations are not entirely unexpected. Compliance measures placed SCS, now the Natural Resources Conservation Service (NRCS), in a quasi-regulatory role, which is in marked contrast to its traditional role of serving clients mostly on a voluntary and willing-cooperator basis. Thus, "cultural" issues have probably retarded effectiveness (91). Also, the novelty and sheer size of the compliance task stretched NRCS personnel and institutions far beyond their traditional resources and roles. Some unevenness in enforcement from region to region could therefore be expected. Whatever the relative roles of these constraints, conservation compliance measures are still inadequately enforced (91).

Regardless of administrative efficacy in implementing them, compliance mechanisms have basic shortcomings as agroenvironmental measures. First, agricultural program payments, i.e., the incentives for achieving compliance, may not be correlated with priority environmental problems (43). Moreover, compliance schemes linked to agricultural program payments lose their effectiveness when they are often needed most. When commodity prices rise and deficiency payments decline, the penalty for not complying with conservation measures also falls. Further, in such a situation, production pressure expands and increases farmers' incentives to farm more intensively or bring new land into production. Finally, as the federal budget shrinks and agricultural program payments fall, the relative scope and effectiveness of compliance programs declines. The last two limitations are expected to become more evident over the next decade, as agricultural trade is liberalized and pressure to cut the federal budget grows.

Agroenvironmental Regulation

Although precise figures do not exist, agriculture appears to be affected less by environmental regulation than other industries. The reasons include agriculture's long history of voluntary subsidy approaches, and its basic structure: diffuse, diverse, and numerous (nearly 2 million) operations that generate mostly nonpoint pollution are difficult to identify, monitor, and regulate. However, when environmental problems are concentrated in certain inputs, subsectors, or local areas (and so can be monitored and measured) and minimum environmental standards have been established, regulatory approaches have been applied. Almost by definition, the regulatory approach is best-suited to cases in which private incentives and public environmental goals are quite disparate.

Pesticides

Pesticide registration is the largest regulatory effort affecting U.S. agriculture. The government began regulating chemicals used in U.S. agriculture at the beginning of the 20th century (75). The goal at that time was to protect farmers from commercial frauds. The history and performance record of the effort delineates the challenges of regulating a diverse and diffuse industry in the face of scientific uncertainty.

The registration and reregistration of products is a complicated and lengthy process that does not appear to satisfy consumers, environmental groups, or industry groups. It can take four to eight years for a product to undergo an elaborate scientific review. At this writing, more than 3,000 chemicals are classified as pesticides under the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA)—a listing that includes active pesticide ingredients and more than 2,000 inert ingredients that are not subject to reviews (96). Perhaps because the review process can be interminable, the vast majority of 880 active pesticide ingredients have not been fully cleared by EPA review and remain effectively unregulated. Further, EPA's efforts apparently have had relatively little effect on the total use or sale of agricultural pesticides (69) Critics allege that severe resource constraints within EPA have hampered its ability to make effective registration decisions. However, evidence suggests that active participation by either environmental or pesticide industry interest groups in the registration process does significantly affect EPA's registration decisions (16).

Pesticide use in the United States grew steadily from 1950 to 1984, but leveled off and started to fall in the mid-1980s (12; table 2-7). On the whole, as fewer acres have been cultivated, smaller amounts of pesticides have been used. The modest decline in the mid-1980s may also reflect the cumulative effects of rising pesticide prices, regulation, and the introduction of more potent compounds. Restrictions on the use of products, posted on legally binding labels, define permissible methods of application, maximum dosages, preharvest intervals, and use restrictions near water.

The threat that a new compound will not be approved by EPA has increased the profit potential of more environmentally benign pesticides, and has encouraged the introduction of a variety of new products (69). Accordingly, although overall pesticide application rates have changed only slightly, the composition of products may have changed much more. Unfortunately, the lengthy and costly EPA review process has probably restricted the rate at which the new, more environmentally benign products appear (62). Efficient regulation can stimulate innovative technologies that reduce the cost of meeting environmental performance standards.

Inevitable uncertainty pervades any evaluation of pesticide policy and programs. Critical assessments seem unending, and there are few definitive conclusions that all sides can endorse. The costs of restricting or banning a pesticide can be reliably estimated in the short run, but long-term estimates are more difficult to make, primarily because it is unclear what problems new products might pose and what kinds of management practices will be used to respond to regulatory action.

Generally, the farm sector as a whole has not suffered economically from pesticide regulation. Consumer prices of products produced with banned or restricted chemicals have risen slightly instead (69). Individually, however, some farmers may lose—or gain—from pesticide regulation. Farmers who have traditionally depended on restricted compounds may grow and sell less, for example, while farmers who have not used such compounds can benefit from the price rises resulting from lower yields and less supply. Farmers who grow crops on which relatively limited amounts of pesticides are used, termed "minor use" crops, such as vegetables, fruits, nuts, and ornamental crops may be particularly disadvantaged. The lack of broad markets that, say, corn and soybeans have, means the cancellation of the registration of compounds for minor used crops can cause significant losses. In effect, because "minor use" compounds have what is considered to be a relatively small market, it is not always profitable to reregister or develop substitutes for canceled compounds.[21] In this context, it is interesting to note that crops requiring "minor use" pesticides may account for fully 45 percent of total U.S. agricultural output and $5 billion in exports (127).

Regulation of individual compounds, whether they are used for soybeans or tomatoes, is not likely to cause severe economic harm when good substitutes are available. However, eliminating a whole class of chemicals without apparent substitutes could cause serious economic hardship in the short run (68). Consequently, the sequence of regulatory decisions, substitutability among chemicals, and the availability of nonchemical alternatives to pesticides are extremely important. The potential risks of using a pesticide must be weighed against costs and the likelihood of developing a substitute to ascertain the magnitude of both short-run and long-run effects.

Even though it is possible to estimate regulatory costs, current science and data usually cannot measure regulatory benefits, or the costs of inappropriate pesticide use. Pesticide-laden runoff that contaminates streams, rivers, and lakes, as well as pesticide residues that leach into groundwater or remain on foods, can damage the environment and have been associated with cancer, developmental impairments, and reproductive problems in humans. Yet the precise nature of the links between pesticides and the damage they cause is poorly understood. Long-term epidemiological (human health) information on the effects of pesticides individually, and in combination with other chemicals or environmental stresses, is lacking. Also lacking is long-term information on how pesticides, individually and in combination with other chemicals and stresses, affect environmental systems. As a result, EPA reviews must often use incomplete and surrogate data to infer risks to humans and the environment from pesticides. Many existing pesticides are being used while tests on them are being completed.

Two important developments in pesticide policy occurred in 1993 (53). A National Academy of Sciences panel on pesticides in the diets of infants and children recommended moving to a health-based standard with careful consideration of children's exposure, and additional testing of pesticides for developmental toxicity (63). The panel noted that because of their weight and diet, children may be at risk of developmental effects from pesticide residues—and so pesticide risk assessments should differentiate between children and adults. In addition, the Clinton administration issued a new pesticide proposal for a unified health-based negligible risk standard for fresh and processed food; a quicker review process, during which registrants must prove that their products are safe or lose approval; special provisions for

[21] EPA has recently been trying to improve minor use registrations. Based on national surveys, the reregistration of about 1,000 minor use pesticides will not be pursued by manufacturers and another 2,600 new pesticides will be needed for minor uses by 1997—creating a need for up to 3,600 minor use products very shortly. To retain important minor use compounds, EPA is: 1) working closely with USDA and an interregional research group that facilitates minor use pesticide research, 2) granting waivers for low volume/minor use data where feasible, 3) moving to revise its crop groupings for residue testing to encourage minor use registrations, 4) encouraging third-party registrations, 5) providing fee breaks and expedited processing, 6) coordinating with agricultural users and the pesticide industry, and 7) considering legislative changes (123).

"minor use" registration and reregistration; and programs to encourage integrated pest management (53,122). These actions, some requiring congressional action, have yet to be approved. Whether they will mark a fundamental policy change for USDA—from primary emphasis on expanding food production by using pesticides to more emphasis on the possible health and environmental risks of pesticides—remains an open question.

Confined Animal Facility Water Pollution

Confined animal operations such as feedlots—some of which, depending on their size and nature, can generate large quantities of nutrients and bacteria—and be a "point" (readily identifiable) source of water pollution. Under the Clean Water Act, such operations fall under regulatory programs to control excessive effluents. States may require the use of specific technology or adherence to certain pollutant limits, as well as monitoring and reporting. EPA delegates the responsibility for implementing such water pollution control provisions, and for achieving designated water quality standards, to states. For its part, EPA is responsible for ensuring compliance with federal legislation.

A review of 10 state programs shows considerable variation in the scope and degree of point-source control programs for these animal facilities (46). Some technical assistance and cost-sharing programs were available in all states through the ACP to help producers comply with the federal standards. Half of the states also provided financial assistance. There are insufficient data to compare the net control costs of these facilities with those of industrial sectors subject to similar regulation. A study conducted for EPA suggested that the applicable regulations were unevenly and weakly enforced (15).

Coastal Zone Water Quality

Pollution of coastal zone waters became a subject of growing concern in the 1980s. As noted earlier in this chapter, coastal estuary water quality has been affected by nitrate and sediment from agricultural sources. Congress enacted a set of Coastal Zone Act Reauthorization Amendments (CZARA) in 1990, which laid out a comprehensive process for improving water quality. Programs aimed at coastal nonpoint source pollution were included. For agriculture, the act sets out specific ways to attain coastal zone water pollution reductions (121). First, farmers in coastal zones are required to adopt "economically achievable" management measures within three years from a list compiled by the federal or state/local agencies. (Presumably, farmers will be given education and technical assistance, but will not be eligible for substantial cost-sharing.) Plans for controlling agricultural and other sources must be submitted by June 1995. If states do not comply with the CZARA provisions, they may possibly forfeit coastal zone development grants and other related federal funds.

During the first stage, the CZARA process requires that certain technologies be implemented for all agricultural land in coastal zones by January 1999. Different technology lists apply to crop and livestock enterprises, for example. Following a two-year monitoring period (to January 2001), the states have three more years to implement additional measures where necessary to achieve specified water-quality standards. States must ensure the implementation of the measures through enforceable mechanisms, including regulation and innovative incentive schemes. Because the CZARA will be implemented over the next several years, its effects on agriculture remain uncertain—but potentially large. For example, almost all counties in Michigan may be affected by CZARA rules because of their proximity to the Great Lakes. One analysis estimates the annual costs of the proposed measures as typically less than $5,000 per farm for most farm sizes (44).

Wetlands Alterations

Section 404 of the 1972 Federal Water Pollution Control Act Amendments regulates actions taken to alter wetlands—including converting them to agricultural uses. Designed primarily to deal with wetlands adjacent to navigable waters, section

404 requires permits administered by the U.S. Army Corps of Engineers for the discharge of dredge and fill material. The role is one long associated with federal regulation of navigation. Most normal agricultural activities were explicitly excluded under section 404 provisions, until President Bush issued his "no net loss of wetlands" (NNL) policy dictum in 1987.

Attempts to implement that policy have necessitated more inclusive definitions of wetlands and have put more agricultural activities under the scrutiny of the section 404 review and permit process. Changes in levees, dikes, and drainage on farmland classified as wetland, and other agricultural wetland conversion, may require a section 404 permit. Under a 1994 agreement between the U.S. Army Corps of Engineers, the FWS, EPA, and the SCS, final rules exempt wetlands converted to cropland before December 1985 from section 404 requirements (131). Most recently, the NRCS was given responsibility for certain aspects of the section 404 program affecting agriculture.

The impact of section 404 wetland permit regulation has been in dispute. Some data imply that the overall restrictiveness has not been great: 67 percent of the applications made in 1990 were approved, 30 percent were withdrawn or processed as general permits, and only 3 percent were denied (42). The time and resources involved in seeking the permit, however, can be considerable. A study of a sample of permit records for 1992 concluded that it took the average applicant 373 days to get through the "individual permit" process, and that 93 percent of the individual permit applications exceeded the 60-day "evaluation-time" target (2). Such individual permit applications normally constitute about 10 to 15 percent of the section 404 permit applications and apply to controversial cases requiring lengthy evaluation. However, when the remaining 85 to 90 percent of general permits are added to individual permits, the average time for the process falls significantly (132). During 1994, the average time was 27 days for the total of more than 48,000 applications, and the time for individual permits fell to 127 days. In addition, the backlog of applications more than two years old fell from 202 to 81 between January 1994 and January 1995 (24). Despite these statistics and the trends they reveal, substantial uncertainty may still exist in farmers' minds about the section 404 process and consequences. In addition to regulatory reform to minimize unnecessary delays and costs, educational programs may be necessary to explain the permitting process and reduce uncertainty for those farmers likely to be little affected.

Endangered Species

The potential application of land use restrictions under the Endangered Species Act to restore threatened and endangered species causes significant worries among agricultural producers who rely on using the lands implicated in recovery plans. The restrictions may affect producers' pesticide use, for example; their plans to convert pasture to cropland; or other development options. Understandably, producers fear that public restrictions will impose costs without compensation.

To date, the impacts on agriculture appear to be isolated cases that may significantly decrease incomes in specific areas. Possible recovery plans invoked for threatened and endangered fish species in Western waters may be broader in scope. Moore and Weinberg (57) report that of the 93 fish species considered threatened or endangered, 67 are found only in Western rivers—a large number of which provide water for agricultural irrigation. Potential recovery plans for the Columbia River's sockeye salmon runs could restrict irrigation in a large section of the Pacific Northwest (Idaho-Washington-Oregon) and impose significant costs on specific agricultural subsectors, even though the costs to the overall regional economy would be small (1). A larger concern centers on potential restrictions based on the number of species expected to become threatened or endangered over the next 10 years. Little systematic analysis of the overall effects on agriculture has been undertaken due to the uncertain path of species preservation actions and required management measures.

Harmful Nonindigenous Species

The accidental importation of harmful nonindigenous species has caused significant commercial losses to agriculture and degraded the environment. However, regulatory mechanisms and rules to screen unwanted species introductions appear incomplete. This issue is discussed in detail in chapter 5.

Stimulating Agroenvironmental Technology Development and Adoption

Despite a broadening environmental agenda, public agricultural research and technology development continues to focus predominantly on increasing production, as it has for most of this century.[22] Public research funds simply have not been targeted to developing technologies aimed at simultaneously enhancing environmental quality as well as agricultural production. Since the 1970s, more than 60 percent of agricultural research by federal research agencies and by state land grant universities has been related to production, while about 10 percent has been dedicated to natural resource or environmental topics (chapter 2). The result has been policies and programs that put production and conservation goals in competition with each other.

Interest in promoting "complementarity" between agricultural production and the environment has grown within the research community, however, and among farm producers, in some agribusinesses, and among consumers. The broad adoption of conservation tillage and growing use of soil nutrient testing, as well as producer involvement in collaborative R&D networks across the country are supportive of the "complementarity" notion (93). Consumers favor a reduction in farm chemical use and show increasing demand for food with fewer chemical residues (81). The market potential for some complementary technologies is reflected in enthusiasm for emerging technologies such as precision farming (described below). Environmental groups also stand to gain from supporting complementary technologies, because they can help achieve lower cost and longer lasting environmental improvements.

Market forces have "induced" agricultural technology innovation that reduces the costs of relatively expensive market inputs, such as land and labor. The costs of these inputs are not difficult to determine. However, the costs of many environmental problems associated with agriculture—such as degraded drinking water or diminishing wildlife habitats—are difficult to capture in the marketplace. Consequently, the environmental costs (and benefits) stemming from agricultural production generally have not been incorporated into the costs farmers pay or the prices they receive for their goods, and there is little impetus for technological innovation that ameliorates, or even addresses, environmental problems.

Public policies, too, are responsible for the technological bias toward agricultural production. Public subsidies may encourage farmers to adopt some technologies to clean up pollution, but as a rule, those subsidies do not act as incentives for developing technologies that will enhance both environmental quality and agricultural output. Pesticide regulation is the major exception, insofar as the restriction of certain agrichemicals essentially creates market incentives for cost-effective, more environmentally sound alternatives. However, regulation may not always be the best approach for stimulating complementary technologies. The present agricultural program regime has fostered a piecemeal approach to agroenvironmental technology innovation: complementarity is the exception rather than the rule, and potential public and private benefits are lost as a result.

[22] Current allocations to agroenvironmental research reflect two special initiatives enacted in the 1985 and 1990 farm bills—the National Research Initiative and the Sustainable Agriculture Research and Education (SARE) program. Both were implemented as competitive grants programs through USDA. The National Research Institute allocates 20 percent of its grants to research topics of natural resource or environmentally related content (65). The SARE program promotes multidisciplinary research applied to farm problems with significant agroenvironmental content.

Technological innovations are not costless. Either private industries or the public sector, or both, must invest in research and development. The chief challenge to public and private technology development will be in identifying critical goals for the sector as it confronts present and future challenges, and stimulating complementary technology innovations that enable individual producers on diverse farms to meet those goals.

The Transition to Complementarity

In practical terms, "technology" means the management scheme by which various practices and inputs—labor, information, machinery, water, chemicals, biological inputs, and capital—are combined into a coherent system to achieve certain goals. As noted in chapter 2, a virtual technological revolution is under way in agriculture, and is having a profound impact on both technological tools and goals. Just as the emphasis on producing abundant food spawned technologies that promoted intensive production and economies of scale, the shift toward a emphasis on both abundant food and environmental quality signals the need for new technologies that prevent pollution and maintain profitability from the outset. For industries such as agriculture, in which nonpoint pollution processes dominate and monitoring enforcement costs are high, preventing pollution may be less expensive and more effective than treating pollution after the fact.

Some analysis suggests that pollution prevention technologies may not be efficient enough to offset the investment required to adopt them and thus not be complementary technologies (97). However, the success of pollution prevention technologies is determined by the efficiency with which it meets socially defined pollution control goals, not simply by its private rate of return in the absence of environmental quality goals. Complementary technologies move a step beyond this standard by requiring environmental quality improvement while maintaining or improving private profitability.

The feasibility of developing and tailoring complementary technologies has not been investigated because, as noted above, there are few market and/or public program incentives to do so. However, some agricultural and environmental technologies currently used suggest that there is great potential for development and adoption of complementary technologies within the agricultural sector. Possible examples of these technologies include: integrated pest management, conservation tillage, soil nutrient testing, rotational grazing, and organic farming systems.

Initiating development of complementary technologies requires first defining the criteria by which their performance will be assessed. For example, critical thresholds for environmental quality and production could be set on a regional or national basis. Environmental quality components include water quality, soil quality, and wildlife habitat criteria and the minimum standards relevant to the region. Similarly, production criteria would capture the crop and livestock regional priorities. Within those critical thresholds (the "feasible set" of technologies), trade-offs between the two goals could provide stimulus for further innovation.

The existence of a feasible range suggests that no single complementary technology will be the "best" choice in all cases and in all regions of the country. There will likely be no "silver bullets." On different kinds of farms, or in the hands of different farmers, the complementarity of a given technology is likely to differ as well.

While complementary technologies may be distinctly different from each other, their successful application uniformly requires sophisticated management skills and a "holistic" or "systems" approach to farm management (94). Thus, the nature of farmer management capacity and goals defines the technology set most relevant to his or her farm. Chief among the tools that may make complementary technologies more feasible are biotechnology, biologically based pest controls, and information technologies.

Biotechnology

Biotechnology involves the insertion of genes carrying desirable traits into plants or animals. As outlined in chapter 2, there are many plausible applacations for biotechnology in agricultural production, ranging from pest resistance in plants to increased growth efficiency for livestock. Most current biotechnology applications are designed primarily to reduce risks associated with crop production or to increase production efficiency, with only incidental consideration of environmental concerns. But there is no reason that biotechnology could not be employed directly toward complementary aims. Biotechnology could be used, for instance, to develop drought-tolerant crops (which could permit a significant reduction in irrigation and its negative environmental consequences). Rather than turning their efforts toward creating Bt-engineered corn (which may enhance the resistance of pests to the toxin) or herbicide-tolerant crops (which do not encourage reduced chemical use or any other conservation practice), scientists might instead investigate the feasibility of conferring inherent resistance to pests without toxins. Markets, however, may not stimulate research and development in that direction because of incomplete environmental pricing.

Testing soil for stored nitrogen helps farmers decide how much fertilizer their crops realty need. In many states, such testing has enabled farmers to save money and curtail nitrate leaching by reducing fertilizer applications. Further development of inexpensive, readily available soil testing technologies could increase the benefits to both farmers and water quality

Biologically Based Pest Controls

The term "biologically based pest controls" refers to a wide variety of products designed to substitute for conventional synthetic insecticides, herbicides, and fungicides. Biologically based pest controls involve the introduction of predators, parasites, pathogens, pheromones or natural competitors specifically to control pests (13). Overall adoption to date of such approaches is low, and biological pesticides currently comprise only a fraction of the total pest control market. Nevertheless, use is growing and is now quite high to control certain pests such as gypsy moths and pest mites in strawberry fields (13).

Interest in exploring biological alternatives to conventional pest control may increase, corresponding to increasing concerns about human safety and environmental quality. The Sustainable Agriculture Research and Education (SARE) program has funded field research into the effectiveness of some biologically based pest management technologies. EPA has designed an accelerated registration process for biologically based pesticides, on the assumption that they are environmentally preferable to synthetic products. Marty may pose fewer threats to human health than some conventional pesticides, but their potential impacts on ecosystems need to be carefully examined.[23]

Information Technologies

Information technologies generally enable farmers to manage their farms in a more sophisticated and cost-effective manner. The range of infor-

[23] The National Academy of Sciences and OTA are both engaged in studies of the status and potential of biologically based pest controls.

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‘Scouting” to determine the abundance of pests in farm fields is an increasing& common aspect of both conventional and alternative methods of pest control. Armed with data collected in the field, with knowledge of pest behavior and the availability of various technologies, farm managers can seek the most effective yet environmentally sound control strategies. Here, researchers observe the effectiveness of an insect trap baited with pheromones.

mation technologies available to farmers is quite broad and the full set of technologies based on intensive use of information continues to evolve. In many cases, these technologies may permit farmers to make market transactions more efficiently (through electronic mail, for instance, and electronic auctions) and minimize their use of certain costly inputs by permitting them to target their resources better (through precise application of agricultural chemicals, computer-simulated trials, “just-in-time” inventory maintenance, and other means). Of particular interest from the environmental perspective is the capacity of informational technologies to ameliorate the negative environmental impacts of agricultural production.

“Precision (or “site-specific”) farming” involves using advanced satellite information-retrieval and information-management products to improve farm management. Among other things, private firms offer precision-farming technologies to make pesticide and fertilizer use more efficient. Global positioning systems (GPS), used in conjunction with ancillary data from census, surveys, or other sources, can help farmers predict crop yields and vary inputs as needed in different parts of even a single field. Used in tandem with computer-assisted or telecommunications-enhanced decision-making software (“expert systems”), these data can serve myriad functions: provide soil quality data to researchers, increase efficiency of input use, predict crop yields for producers, and anticipate and control potential environmental problems resulting from the adoption of certain production practices. Theoretically, precision farming can help farmers reap broad environmental benefits while enhancing the productivity of their farms. These technologies are still being developed, however, and their full potential to satisfy the criteria for complementarity remains unknown.

Other systems-oriented, information-intensive technologies may also help farmers tailor their management of inputs and pest control to their own needs. Perhaps the most prevalent approach, typically called integrated pest management (1PM), involves “scouting” or monitoring fields for the presence of target pests. Based on scientific principles of pest reproduction and behavior, pesticide applications can be very specific. Although integrated pest management is not always synonymous with reduced agrichemical use, it is less ecologically intrusive than repeated, blanket spraying of pesticides.

Another system-based alternative, integrated crop management, uses certain crop mixes to create an inhospitable habitat for pests and boost production. Many of the approaches to production developed through the SARE program and through state-supported and private sustainable agriculture networks use information intensively to manage production and environmental goals.

In the end, these and other technologies discussed above could make it easier for farmers to decide how to achieve optimal yields as well as maintain soil quality, safeguard water quality, and minimize degradation of wildlife habitats. To the extent that new technologies help operators and public agencies develop and use a better understanding of how agricultural systems and environmental interaction affect both on-farm productivity and on-site and off-site resource quality, they may enhance the environmental agenda for agriculture while enhancing on-farm profitability. In general, the future significance of these technologies for agriculture and the environment depends on: 1) their practical relevance to production, 2) their availability, and 3) their ultimate rate of adoption (table 4-2). Even though the potential for complementarily is high, technologies that simultaneously address production and environmental goals may not become broadly available until specific environmental and agricultural production goals are set to provide signals for private markets and guide public research allocations.

TABLE 4-2: Emerging Technologies and Potential Environmental Effects of Their Adoption

Technology category	Agricultural application[a]	Availability of technology	Factors affecting adoption	Potential environmental benefits or costs
Biotechnology	▪ weed control (c) ▪ insect control (c) ▪ disease control (c,l) ▪ reproductive control (1) • market readiness (c) ▪ herbicide resistance (c)	▪ significant public, private research • regulatory process Incomplete ▪ few current applications satisfy complementarily criteria	▪ risks of transition ▪ consumer acceptance ▪ management ability ▪ relevance to on-farm goals ▪ rates of technology development and transfer " cost	▪ may reduce or substitute for some pesticide use ▪ may Improve agricultural nonpoint pollution problems ▪ may reduce poisoning of nontarget plant and animal species ▪ may create problems with weediness and nonindigenous species ▪ may reduce stress on natural inputs through enhanced efficiency ▪ benefits may be vulnerable to pest resistance
Biologically based Pest Controls	▪ weed control (c) • insect control (c) ▪ pathogen control (c)	▪ uneven public, private research and development ▪ limited number of products ▪ some active public sector uses ▪ potential for complementarity not clearly established	• as above	▪ as above ▪ may enhance biodiversity in agroecosystems ▪ may reduce biodiversity when biocontrol diminishes nontarget species
Informatlon-Intensive Management[b]	▪ weed control (c) ▪ insect control (c) ▪ enterprise planning (c,l,m) ▪ resource monitoring (ae) ▪ whole farm planning (c,l,m,ae)	▪ emerging private, public research ▪ limited number of applications ▪ some active private sector uses of prototypes ▪ potential for complementarily not clearly established	▪ as above	▪ as above ▪ may facilitate complementarity between production and agroenvironmental planning ▪ may reduce public cost of monitoring of soil, water conditions ▪ may encourage cooperation between private and public resource management

[a] Activity category: c= crops, I = livestock, m= marketing, ae= agroenvironmental
[b] These include integrated crop management, certain nutrient management schemes, whole farm planning approaches, integrated pest management, and other pollution-prevention technologies.

SOURCE: Office of Technology Assessment, 1995

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Appendix 4-1: National Primary Drinking Water Standards

Contaminants	MCL (mg/L)	Potential health effects from ingestion of water	Sources of contaminant in drinking water
Giardia Iambia	4 0	Skeletal and dental fluorosis	Natural deposits; fertilizer, aluminum industries, water additive
Total Coliform*	< 5%+	Indicates gastroenteric pathogens	Human and animal fecal waste
Turbidliy*		Interferes with disinfection, filtration	Soil runoff
Viruses	TT	Gastroenteric disease	Human and animal fecal waste
Mercury* (inorganic)	0.002	Kidney, nervous system disorders	Crop runoff; natural deposits, batteries, electrical switches
Nitrate'	10	Methemoglobulinemia	Animal waste, fertilizer, natural deposits, septic tanks, sewage
Nitrite	1	Methemoglobulinemia	Same as nitrate; rapidly converted to nitrate
Alachlor	0.002	Cancer	Runoff from herbicide on corn, soybeans, other crops
Aldicarb sulfone*	0002	Nervous system effects	Biodegradation of aldicarb
Aldicarb sulfoxide*	0.004	Nervous system effects	Biodegradation of aldicarb
Atrazine	0.003	Mammary gland tumors	Runoff from use as herbicide on corn and noncropland
Carbofuran	0.04	Nervous, reproductive system effects	Soil fumigant on corn and cotton; restricted in some areas
2,4-D*	0.07	Liver and kidney damage	Runoff from herbicide on wheat, corn, rangelands, lawns
Dibromochloropropane	0.0002	Cancer	Soil fumigant on soybeans, cotton, pineapple, orchards
Lindane	0.0002	Liver, kidney, nerve, immune, circulatory	Insecticide on cattle, cotton, soybeans, canceled 1982
Methoxychlor	004	Growth, liver, kidney, nerve effects	Insecticide for fruits, vegetables, alfalfa, livestock, pets

(continued)

Contaminants	MCL (mg/L)	Potential health effects from ingestion of water	Sources of contaminant in drinking water
Pentachlorophenol	**0.001**	**Cancer, liver, and kidney effects**	Wood preservatives, herbicide, cooling tower wastes
Toxaphene	0.003	Cancer	Insecticide on cattle, cotton, soybeans; canceled 1982
2,4,5-TP	0.05	Liver and kidney damage	Herbicide on crops, right-of-way, golf courses; canceled 1983
Dalapon	02	Liver, kidney	Herbicide on orchards, beans, coffee, lawns, road/railways
Dinoseb	0.007	Thyroid, reproductive organ damage	Runoff of herbicide from crop and noncrop applications
Diquat	002	Liver, kidney, eye effects	Runoff of herbicide onland, aquatic weeds
Dioxin	0.00000003	Cancer	Chemical production byproduct, impurity in herbicides
Endothall	01	Liver, kidney damage	Herbicide on crops, land/aquatic weeds, rapidly degraded
Endrin	0002	Liver, kidney, heart damage	Pesticide on insects, rodents, birds; restricted since 1980
Glyphosate	0.7	Liver, kidney damage	Herbicide on grasses, weeds, brush
Hexachlorobenzene	0001	Cancer	Pesticide production waste byproduct
Hexachlorocyclopentadiene	005	Kidney, stomach damage	Pesticide production intermediate
Oxamyl (V ydate)	02	Kidney damage	Insecticide on apples, potatoes, tomatoes
Picloram	05	Kidney, liver damage	Herbicide on broadleaf and woody plants
Simazine	0004	Cancer	Herbicide on grass sod, some crops, aquatic algae
1,2,4-Trichlorobenzene	0.07	Liver, kidney damage	Herbicide production, dye carrier
Arsenic'	005	Skin, nervous system toxicity	Natural deposits; smelters, glass, electronics wastes, orchards

Appendix 4-2: Listing of Federal Conservation and Environmental Programs Related to Agriculture[1,2]

Education and Technical Assistance

1. Comprehensive State Ground-Water Protection (EPA)
2. Conservation Technical Assistance
3. Extension Education
4. Flood Prevention
5. Forest Stewardship
6. Resource Conservation and Development

Research or Data Activities

7. Agricultural Research Service
8. Army Corps of Engineers (U.S. Army)
9. Bureau of Land Management (DOI)
10. Bureau of Reclamation (DOI)
11. Cooperative State Research Service
12. Environmental Protection Agency (EPA)
13. Economic Research Service
14. Fish and Wildlife Service (DOI)
15. Forest Service
16. Geological Survey (DOI)
17. National Agricultural Library
18. National Agricultural Statistics Service

19-24. Natural Resources Conservation Service
- 19. National Resources Inventory
- 20. Resource Conservation Act Appraisal
- 21. River Basin Surveys
- 22. Soil Surveys
- 23. Snow Surveys
- 24. Plant Material Centers

Regulation or Compliance

25. Animal and Plant Health Inspection Service
26. Coastal Nonpoint Pollution Control (NOAA and EPA)
27. Conservation Compliance
28. Dredge and Fill (wetlands) Permits (U.S. Army Corps of Engineers)
29. Endangered Species Protection (DOI)
30. National Pollution Discharge Elimination System Permits (EPA)
31. Pesticide Registration (EPA)
32. Pesticide Record Keeping
33. Safe Drinking Water Act (EPA)
34. Sodbuster
35. Swampbuster

[1]Programs are categorized based on their predominant program approach.
For a brief description of the programs, see U.S. Department of Agriculture, Economic Research Service, Natural Resources and Environmental Division "Agricultural Resources and Environmental Indicators," *Agricultural Handbook No. 705*, December 1994, pp. 162-174.

[2]Lead agencies are identified for programs outside the U.S. Department of Agriculture: EPA = Environmental Protection Agency; DOI = Department of the Interior; NOAA = National Oceans and Atmospheric Administration.

Subsidies, Compensation, and Public Works

36. Agricultural Conservation Program
37. Clean Lakes Program (EPA)
38. Colorado River Salinity Control
39. Conservation Loans and Easements
40. Conservation Reserve
41. Environmental Easement Program
42. Emergency Conservation
43. Emergency Watershed
44. Endangered Species Conservation (DOI)
45. Farmland Protection
46. Flood Control
47. Forestry Incentives
48. Forestry Stewardship Incentives
49. Great Plains Conservation
50. Integrated Farm Management
51. Integrated Pest Management
52. National Estuary (EPA)
53. Nonpoint Source (water quality) (EPA)
54. Rural Clean Water Program
55. Range Improvements (DOI, Bureau of Land Management)
56. Small Watershed
57. Water Bank
58. Water Development and Management (DOI, Bureau of Reclamation)
59. Wetlands Conservation (DOI)
60. Wetlands Reserve

SOURCES U S Department of Agriculture, Economic Research Service, Natural Resources and Environment Division, "Agricultural Resources and Environmental Indicators, " *Agricultural Handbook No. 705,* Washington, DC, December 1994, and Jeffrey A Zinn, "Implementation of Resource Conservation Programs Enacted in the 1990 Food, Agriculture, Conservation and Trade Act, " memorandum to Congress, Congressional Research Service, Jan 31, 1992

Appendix 4-3: USDA Conservation Expenditures, by Activity and Program Fiscal Years 1983-1995

APPENDIX 4-3: USDA Conservation Expenditures, by Activity and Program, Fiscal Years 1983-1995[1]

Activity/program	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994 enacted	1995 enacted
							$ million[1]						
1. Technical assistance, extension, and administration:													
Soil Conservation Service (SCS) programs—													
Conservation Technical Assistance (CTA)	276.9	293.7	302.0	286.7	332.0	366.4	386.7	396.7	426.5	477.9	515.2	502.6	500.5
Great Plains Conservation Program (GPCP)	9.1	9.1	9.1	8.9	9.1	8.7	8.2	8.0	8.3	9.1	8.9	9.3	8.9
Resource Conservation & Development (RC&D)	16.3	16.3	17.8	17.4	17.8	18.2	18.4	23.1	24.2	26.0	29.9	28.4	28.8
Small Watershed Program (planning)	8.9	8.7	8.9	8.5	8.7	8.7	8.7	8.8	9.2	9.5	9.5	10.9	10.5
Watershed Protection/Flood Prevention	101.6	75.7	76.9	77.8	68.1	67.7	65.9	63.2	70.3	74.3	80.4	83.5	55.9
Subtotal SCS	412.8	403.5	414.7	399.3	435.7	469.6	487.9	499.8	538.5	596.8	643.9	634.7	604.6
Agricultural Stabilization & Conservation Service (ASCS) programs—													
Agricultural Conservation Program (ACP)	11.0	11.2	11.2	10.5	9.3	11.2	10.1	11.3	10.6	10.8	11.2	9.7	5.0
Colorado River Salinity Control Program	0.0	0.0	0.0	0.0	1.4	1.8	2.0	4.4	5.9	5.9	5.5	4.9	1.5
Conservation Reserve Program (CRP)	0.0	0.0	0.0	10.8	21.9	5.6	27.9	16.4	5.7	11.4	8.9	4.7	0.0
Emergency Conservation Program (ECP)	0.1	0.7	0.6	0.2	0.1	0.2	0.4	0.6	0.5	0.8	1.5	1.0	0.0
Forestry Incentives Program (FIP)	1.3	1.3	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.3	0.0
Rural Clean Water Program (RCWP)	-0.9	0.3	0.0	3.4	2.5	-0.0	-0.7	0.9	0.8	0.4	0.0	0.0	0.0
Water Bank Program (WBP)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.7	1.1	1.1	0.4	0.0
Wetland Reserve Program (WRP)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.9	3.5	7.7
ASCS salaries & exp., conservation	32.8	35.3	33.1	37.3	47.6	61.4	62.4	60.2	73.8	72.6	65.3	67.6	62.8
Subtotal ASCS	44.3	48.7	46.1	63.3	84.0	81.4	03.3	95.6	99.2	104.3	99.6	93.1	77.0
Extension Service (ES) conservation	15.9	16.0	16.4	16.3	15.7	18.1	19.8	23.5	29.4	31.1	31.1	33.8	33.8
Forest Service (FS) programs	14.4	9.7	9.8	9.5	10.0	10.8	13.0	19.2	47.4	56.5	60.7	62.5	68.1
Subtotal Tech. asst., ext., and admin.	487.4	477.9	487.0	488.4	545.4	579.9	624.0	638.1	714.5	788.6	835.3	824.1	783.5
2. Cost sharing for practice installation:													
ASCS programs—													
Agricultural Conservaiton Program (ACP)	176.5	174.5	179.2	129.7	172.6	186.6	174.0	187.8	171.6	179.1	182.8	183.0	95.0
Colorado River Salinity Control Program	0.0	0.0	0.0	0.0	2.5	3.1	3.4	6.0	8.9	8.8	8.2	8.2	3.0
Conservation Reserve Program (CRP)	0.0	0.0	0.0	12.4	245.6	284.8	182.3	118.1	40.9	39.3	32.0	14.1	4.3
Emergency Cconservation Program (ECP)	13.9	16.4	4.9	6.6	5.3	5.7	6.1	17.9	8.8	10.3	42.0	24.0	0.0
Forestry Incentives Program (FIP)	11.3	11.1	11.5	9.8	10.7	10.6	11.0	10.2	12.4	11.5	11.2	11.5	6.0
Rural Clean Water Programj (RCWP)	2.5	0.0	1.9	10.6	0.0	2.1	0.8	0.3	0.1	0.0	0.0	0.0	0.0
Wetland Reserve Program (WRP)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	5.3	7.0
Subtotal ASCS	204.2	202.0	197.5	169.1	436.7	493.0	377.6	340.3	242.7	249.0	276.3	246.1	115.2

(continued)

APPENDIX 4-3 (Cont'd.): USDA Conservation Expenditures, by Activity and Program, Fiscal Years 1983-1995[1]

Activity/program	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994 enacted	1995 enacted
							$ million[1]						
FS Stewardship Incentives Program (SIP)	0 0	00	00	00	00	00	0 0	00	199	0 8	178	179	183
SCS Great Plains Conservation Program (GPCP)	12,2	123	125	115	114	118	122	129	164	162	164	164	6 3
Subtotal Cost-sharing	2164	2143	2100	1807	4481	5048	3898	3532	2790	2660	3105	2804	1399
3. Public works project activities (SCS):													
Emergency Watershed Protection	225	220	5 0	797	148	135	100	949	200	700	731	2480	1250
Flood Prevention (operations)	227	9 9	139	191	115	113	128	160	128	214	238	229	0 0
Resource Conservation and Development (RC&D)	144	9 7	8 5	77	72	70	67	4 2	5 7	6 5	2 6	4 6	40
Small Watershed Program (operations)	160.6	876	880	808	827	834	837	817	826	896	1013	1069	141
Subtotal SCS public works projects	220.2	1291	1154	1873	1162	115.2	1132	1968	121.1	1875	2008	3824	1431
4. Rental and easement payments (ASCS):													
Conservation Reserve Program (CRP)	0.0	0.0	0 0	0 0	4100	7601	11621	1393.7	15901	16125	15100	17292	1739.0
Water Bank Program (WBP)	88	8 8	8 8	8 4	8 4	8 4	90	122	131	171	171	74	00
Wetland Reserve Program (WRP)	0.0	0 0	0 0	0 0	0 0	0 0	00	0 0	0 0	0 0	4 4	47.3	630
Subtotal rental and easement payments	88	8 8	8 8	8 4	4184	7685	1171.1	14060	16032	16296	1531 5	17839	18020
5. Conservation data and research:													
Agricultural Research Service	635	637	637	624	593	605	659	736	736	739	743	767	760
Cooperative State Research Service	279	296	328	313	310	331	345	406	50.6	497	517	512	432
Economic Research Service	5 0	7 7	5 4	40	4 0	31	30	4 6	5 5	5 8	6 3	5 0	40
Forest service (forest environment research)	197	204	203	239	282	293	31 1	353	407	390	418	420	422
National Agricultural Library (water quality)	0 0	00	0 0	0 0	0 0	0 0	0 0	0 3	0 3	0 3	0 3	0 3	03
SCS programs:													
River basin surveys	164	156	149	14.2	121	121	121	123	128	133	133	135	130
Soil surveys	514	535	548	543	582	677	682	681	698	726	72.6	739	726
Plant materials centers	3 8	40	41	3 9	4 6	4 9	5 0	7 2	7 9	81	81	8 9	81
Snow surveys	3 8	39	4 0	3 8	50	5 4	55	5 4	5 6	5 7	5 7	5 8	58
Subtotal SCS	755	770	778	762	797	900	908	930	960	996	996	1021	99.5
Subtotal conservation data and research	1916	1984	2000	1978	2022	2160	2253	2473	2667	2683	2740	2773	2652
6. Conservation compliance and sodbuster (ASCS & SCS) (expenditures are included in other programs listed above):													
Total	1,1244	1,0285	1,0212	1,0625	1,7303	2,1843	2,5234	2,8414	2,9845	3,1400	3,1521	3,5481	3,133.7

[1]Derived from material provided by the Off Ice of Budget and Program Analysis (OBPA) USDA.

SOURCES: U.S. Department of Agriculture, Economic Research service "Agricultural Resources, Cropland, Water, and Conservation Situation and Outlook Report, " Agricultural Report 30, May 1993, and U.S. Department of Agriculture, Economic Research Service, Natural Resources and Environment Division, "Agricultural Resources and Environmental Indicators," *Agricultural Handbook 670,* December 1994

Expanding Agricultural Trade and the Environment: Complementary or Conflicting? 5

As global economic integration proceeds, and as domestic and international environmental priorities broaden, increasing concern has focused on how trade might affect the environment—and how environmental programs might affect trade.Whether the expanding trade and environmental forces can work together, or whether they necessarily conflict, has been a matter of prolonged debate (10,18). In fact, in the space of 20 years, the scope of the debate has widened from economic and environmental issues under U.S. jurisdiction to include international commerce and global environmental questions. The simple label "trade and environment" consequently covers a large, complicated, and ever-growing web of topics that are crucially important to legal, economic, and environmental interests alike (23,64).

Chief among the most striking developments has been a steady rise in world trade. The nominal value of world agricultural trade, for example, has risen fivefold since 1970, from about $40 billion to more than $200 billion (86). The North American Free Trade Agreement (NAFTA) and the Uruguay Round Agreements (URA) of the General Agreement on Tariffs and Trade (GATT) will further fuel that trade. Other regional agreements designed to lower trade barriers, such as the Mercado Comundel Sur (MERCURSOR) pact among Argentina, Brazil, Uruguay, and Paraguay, will likely do the same.

Coupled with rising production for domestic consumers, increases in agricultural trade placed new pressures on the U.S. environment in the 1970s and early 1980s. As they produced more, farmers used more machinery, pesticides, and fertilizers, and irrigated more acres. Technological advances made it less costly to convert prairies, wetlands, and other areas to farmland. As a re-

sult, all levels of government introduced more environmental management initiatives affecting agriculture. (See chapter 4 and also chapter 6, which documents similar trends in national agroenvironmental programs among selected trading partners and competitors.) While the pressures on input use abated slightly in the late 1980s and early 1990s, the potential exists for a recurrence with trade expansion.

Multilateral and global environmental initiatives have multiplied as well. Since the early 1970s, both developed and developing nations have been increasingly active, and have sought cooperation on transboundary environmental problems such as ozone depletion, endangered wildlife, and greenhouse gases. Several major international conferences have marked the expanding multilateral environmental interests—U.N. Stockholm Conference (1972) leading to the United Nations Environment Program (UNEP), the 1987 World Commission on Environment and Development addressing sustainable development, and the 1992 U.N. Conference on Environment and Development held in Rio de Janeiro, Brazil, producing climate change and biodiversity conventions.

Such conferences and other fora have devoted considerable attention to trade and environment issues, but definitive answers to fundamental questions remain elusive. How and how much will expanded trade ultimately affect national and international environments? Will domestic and multilateral environmental protection measures conflict with liberalized trade? Or are the two forces basically complementary?

It is difficult to answer these questions definitively because research on them is immature (78). Imperfect knowledge of how new global trade regimes, new environmental management agreements, and the markets for traded goods operate—and, ultimately, of how the environment is related to agriculture—have made the agricultural trade/environment debate to this point primarily a conceptual exercise. Most analyses have focused on defining terms and potential complementarities and conflicts, instead of providing direct, quantifiable links between agricultural trade and environmental conditions, or between environmental management and trade flows. A growing number of quantitative studies are analyzing the size and nature of the domestic and international linkages (for example, 39,83), but much more effort is required.

This chapter examines what is currently known about how agricultural trade and the environment affect each other in the United States—and advances hypotheses about their future relationship. International developments that complement or work against national interests are also covered. For the purposes of this chapter, the term "environment" refers to natural resources such as water, soil, wildlife, and so forth. (See chapter 4.) Food safety questions are, for the most part, not addressed.

Pearson lucidly defines four trade and environment policy issues that are the collective focus of this chapter. First is the effect of environmental regulation on trade. According to some schools of thought, costly environmental regulations can force domestic producers to lose export markets or move overseas. As this chapter will demonstrate, however, studies of nonagricultural industries indicate that exports have been little affected and that overseas migration has not been significant overall. Because the U.S. agricultural sector is subject, for the most part, to voluntary conservation and environmental programs implemented with subsidies, the overall effects of these programs on trade flows and firm location should be negligible as well. Moreover, many competitors abroad must comply with similar agroenvironmental programs. (See chapter 6.)

On the other hand, some agricultural sectors may suffer from environmental regulations in the short term. A case in point is the fruit and vegetable sector, which relies on the pesticide methyl bromide for crop production, but also to treat food exports and imports. Methyl bromide depletes the ozone layer, however, and its use is to be phased out by 2001 under the Montreal Protocol on Substances that Deplete the Ozone Layer and the U.S. Clean Air Act. Clearly then, the effects of a broadening environmental agenda on trade will depend on the specific types of environmental programs implemented. Complementary research and technology developments targeted to achieve environmental and trade objectives simultaneously are a sensible option to reduce conflicts. (See chapter 4.)

Second to be considered is the role of product standards. National product standards, such as tolerance levels for pesticide residues, serve as nontariff measures to screen certain imports. The URA established new health and safety, as well as "technical barriers to trade," codes that address this issue. Among other things, the codes specify that product standards should be based on science and restrict trade no more than necessary to achieve a nation's desired level of protection. However, certain agricultural product standards are crucial to addressing environmental ills. For example, keeping harmful nonindigenous species (HNIS) out of the United States (now a major environmental concern) depends primarily on enforcing measures covered by the codes, such as quarantines. It is not clear whether these kinds of standards will come under fire as unjustifiable barriers to trade. If they do, only future rulings by the World Trade Organization (WTO), the trade community's successor to GATT, will determine their status.

The third major topic to be addressed in this chapter is the effect of trade liberalization and expansion on the environment. NAFTA and the URA do not require the United States to reduce current commodity program payments affecting production, or to "decouple" (i.e., separate) the payments from levels of production. Thus, potential environmental changes from commodity program reform should not be expected. Shifts in agricultural production that result from the new trade agreements will likely cause little overall change in U.S. environmental conditions. Indeed, environmental conditions may improve in some areas, as imports displace environmentally damaging domestic production. Certain other areas—such as border zones, where trading could flourish—may come under increased environmental stress, and HNIS, such as invasive weeds on rangelands, could pose new commercial and environmental risks as they enter through trade pathways. Controlling domestic environmental quality hinges principally on how U.S. agroenvironmental programs are run. These programs are not, at this writing, wholly effective: they do not offer comprehensive and enduring environmental coverage, or incentives for complementary technology research and development.

Expanding agricultural trade may pose special risks for developing countries that have inadequate environmental programs and would respond to higher world prices by producing more products for export. Pressures on transboundary and global environmental resources of interest to the United States, such as border water resources and habitats for migratory wildlife, may result in significant costs. The present patchwork of multilateral environmental agreements does not appear able to systematically address this kind of dilemma.

Fourth, and finally, this chapter looks at how trade measures are used to meet international environmental objectives. NAFTA and the URA were the first trade agreements to incorporate significant environmental provisions, but the ultimate efficacy of those provisions depends on future political dynamics. In contrast, the use of trade measures in a limited number of international environmental agreements has been demonstrably effective. Current WTO rules do not specifically address the use of international environmental trade measures, and therefore clear guidelines are not at hand. Further, critical questions about the conditions justifying unilateral or multilateral actions and extraterritorial objectives remain unanswered. Such "offensive" environmental trade measures have not been widely applied to agriculture, although they may be in the future. Clear rules promulgated by the WTO would assist environmental and trade efficiency. An international organization responsible for global environmental management could work with the WTO to ensure that both global trade and environment needs receive appropriate consideration.

Based on careful examination of the issues, it is OTA's conclusion that efforts to expand agricultural trade and upgrade environmental quality can complement each other, if appropriate envi-

For the first time in history the signing of a trade pact-the North American Free Trade Agreement-was accompanied by an environmental side-agreement to pursue regional environmental protection.

ronmental management programs are in place and are properly run. Unfortunately, current programs at domestic and international levels do not ensure that this will happen. Reconstitution and retargeting of environmental programs; more funding for technology research and development that aids both trade and environmental quality; introduction of new institutions; and greater levels of multilateral cooperation are essential.

EFFECTS OF ENVIRONMENTAL PROGRAMS ON TRADE COMPETITIVENESS

As environmental concerns escalated in the early 1970s, the trade community began to worry that a country's efforts to promulgate environmental legislation might impose high compliance costs on its industries-and so damage their ability to compete in international markets (58). Further, some argued that if the compliance costs were subsidized by governments, environmental resources would continue to be undervalued and squandered. The Organization for Economic Cooperation and Development (OECD) addressed the issue back in 1972, when it published its ***Guiding Principles Concerning the International Economic Aspects of Environmental Policies.*** This document marked the international debut of the "polluter-pays principle" (PPP), which, simply stated, requires polluters in the private sector, and not governments, to pay for the environmental degradation they cause.

The PPP reflects a sound trade and environmental policy principle: unless private parties pay the full amount it costs them to produce goods (and eventually pass those costs onto consumers through higher prices), environmental and other resources will be misused and trade will be inefficient (3,56). The actual costs of environmental degradation are usually not included in the prices producers pay or in the prices they charge to consumers because, in economic terms, property rights for many environmental resources are undefined or work poorly (57). Essentially, the full costs of using environmental resources in agricultural production—or of inadvertently degrading them through agricultural practices—are left out of the market prices for agricultural goods. A classic example of this dilemma is field runoff carrying sediment, fertilizer, or pesticides, which pollutes water downstream. The cost of the pollution is not paid by the polluter, and so he or she does not incorporate that cost into the price of his or her products. A related principle implies that there will be insufficient positive environmental services unless the parties that generate those services are subsidized. An agricultural example might be compensating farmers for environmental benefits that also accrue to other parties, such as providing habitat for migratory wildlife.

If significant environmental problems stemming from freer trade are ignored by markets, then freer trade does not necessarily guarantee that a society's welfare will improve—that is, that a society will be on the whole better off than it was before it liberalized trade (3). Prices that do not take all costs into account also convey incomplete signals to private and public environmental technology research and development. (See chapter 4.) Theoretically, appropriately targeted policies that do take external environmental costs (and benefits) into account could lead to gains in both trade and environmental quality (3). Unfortunately, accurate and comprehensive "environmental" or "natural resource accounting," which would assess those costs and benefits, is not yet possible (9).

For governments not to levy an environmental charge under the PPP means that parties other than the polluter lose income or otherwise have to pay a "significant" cost for what the polluter has done. In some cases, the environmental consequences of agricultural production may not result in "significant" external costs. In others, farmers may have economic incentives to address the environmental problems they have caused, because the damages directly affect their assets and/or profits. Losses of soil productivity due to erosion fall into this category. Clearly, a first step in remedying environmental problems, whether they are generated by trade or domestic sources, is to determine what kinds of activities result in significant external effects, whether negative or positive.

Governments use regulatory standards, taxes, subsidies, and other policy instruments to "pay" for negative or positive environmental effects. But public subsidies of pollution abatement costs, for example, violate the PPP and have been discouraged by the Organization for Economic Cooperation and Development (OECD) and GATT accords.[1] Despite such arguments against subsidies, they remain the dominant approach in U.S. agroenvironmental management programs. (See chapter 4.) Other industrial countries have been similarly disinclined to factor the PPP into their agroenvironmental policies (76). However, the use of environmental subsidies in agriculture is expanding, and could pose future problems.

Impacts on Agriculture

Like producers in other industries, farmers fear that the costs of complying with environmental programs will significantly constrain their ability to compete with foreign firms. For agriculture, such diminished competitiveness has not been a major issue until now, because most conservation and environmental programs have been voluntary and implemented with subsidies, or have been a side requirement of commodity program subsidies. (See chapter 4.) There are currently regulations pertaining to pesticide registration, water runoff from confined animal operations, and land use controls to protect endangered species. Also,

[1] Because not all environmental effects are counted in the market, it is argued, polluters, in effect, receive an implicit subsidy (54,71).

potential regulations may be used to improve the water quality of coastal zones. But the prospect of more, and more extensive, regulations has generated worries about their impacts on competitiveness. At this writing, the net costs of environmental programs affecting U.S. agriculture, including subsidies, regulatory expense, and private benefits, are unknown. Some studies have attempted estimates, but their data are incomplete (29).

Because there is little compliance cost information available for agriculture, it is useful to look at how trade in other U.S. industries has been affected by the environmental regulations that they have been forced to follow for more than 20 years. The evidence indicates that pollution abatement costs (PACs) do not have a large influence on overall trade patterns, nor do they, on the whole, induce industries to migrate overseas (19,74,80). Some sectors with relatively high PACs, such as chemical manufacturers, may be disadvantaged because of the kinds of pollution they produce and/or the kinds of regulations they face. Still, such cost differences should be compared with the environmental benefits they create to determine their benefit-cost consequences for the nation.

Whether agriculture is or will become a sector with high PACs is, as suggested above, not clear. Data are incomplete, and the provisions of future environmental programs are unknown. Current environmental regulations, as discussed in chapter 4, do not engender large overall costs for agriculture that negatively affect trade. More likely, if trade is adversely affected, it is because current agroenvironmental programs predominantly use subsidy approaches that do not conform to the PPP. For the United States, the magnitude of subsidies have been small to date, about 4 percent of total product value, suggesting small overall effects on trade (76). However, those subsidies are not restricted in total by NAFTA or the URA, and are growing. The largest subsidy programs—acreage set-asides such as the Conservation Reserve Program (CRP), which restrict production—are those most likely to interfere with agricultural trade.

Although the overall effects may be negligible, specific sectors may suffer as the result of particular pollution problems and regulations. The methyl bromide controversy is an example that is often cited. Methyl bromide is a chemical used as a soil fumigant pesticide in the production of crops, and in the treatment of agricultural imports and exports. Methyl bromide also depletes ozone in the atmosphere, and its use will be phased out in the United States by 2001 under the Montreal Protocol and U.S. Clean Air Act. In the South, the production and/or export of cotton, tobacco, citrus fruits, and peanuts may be reduced if the use of methyl bromide is restricted (43). Forsythe and Evangelou (27) estimate that without methyl bromide, fresh fruits and vegetables imports would cost the United States $1.1 billion more over five years. This estimate is based on the short- and medium-term costs of substituting irradiation treatment for methyl bromide, and does not take into account any possible environmental benefits. Ferguson and Padula (26) estimate the economic costs of banning methyl bromide as a soil fumigant at $1 billion per year for producers and consumers. Their estimate does not incorporate the development of substitute technologies before the ban that might lower costs. The regional distribution of costs are uneven, concentrating in the southeastern states and California. Yarkin, et al. (92) estimate that California walnut growers would lose $9.9 million (or about 3 percent) of their gross returns in the short term from the phase-out. Long-run impacts again depend on the development of substitute treatments, and whether other countries follow the ban. The impacts of such bans generally tend to moderate in the longer run, as new technologies emerge to substitute for the restricted product.

Gauging impacts on future competitiveness requires details on the nature of new conservation and environmental programs. The discussion of agriculture's broadening environmental agenda in chapter 4 suggests that environmental management costs could rise appreciably, in particular for sectors that generate large amounts of very damaging wastes. Depending on the extent and nature of the management programs, U.S. agricultural competitiveness in world markets could be reduced—a hazard for all sectors subject to increasing environmental compliance costs (80). Any loss in trade profits, however, should be weighed against environmental gains that accrue from the program requirements. Although the results pertain to an export competitor rather than to the United States, analyses by Lueck and by Halley empirically estimate that under some potential European Union (EU) agricultural nitrate reduction and water quality programs, EU food production and trade could decline. (See chapter 6 for a more detailed discussion of this topic.) In such an instance, the United States could gain some of that market—but it would have to consider all of the significant environmental effects stemming from expanded production to ensure a net benefit.

TRADE AND ENVIRONMENTAL EFFECTS OF PRODUCT STANDARDS

National product standards relating to human, animal, or plant health, and to the conservation of natural resources, can affect the ability of traded goods to enter foreign markets. Permissible pesticide residue levels, auto emissions technology requirements, and other standards are intended to treat the effects of using a product, whether of domestic or foreign origin. Such standards may be used legally under WTO rules[2] by the United States to regulate imported goods, or by foreign countries to control U.S. exports—but they must be applied uniformly to the product in question, whether imported or domestically produced, to avoid discrimination against foreign products. Thus, the WTO rules for product standards simultaneously protect U.S. agricultural exporters from unfair requirements in foreign markets and protect U.S. citizens against food, environmental, or other risks caused by imported goods.

During the early 1970s, concern centered on the potential for product standards to serve as nontariff barriers. Pearson notes that some individuals in the trade community have historically responded by advocating harmonization of standards whenever possible, to avoid barriers and reduce the high costs of selling in markets that each have different standards for exporters to meet. Devices such as the Codex Alimentarius Commission (which aims to harmonize global food and agricultural standards); GATT rules on health, safety, and other technical measures; and regional trade groups like the EU have facilitated harmonization. The potential benefits of harmonization include minimizing the use of product standards as trade barriers, as well as reducing the high costs of design, production, inventory, and information required to sell in a variety of markets with different standards (58). The potential costs of harmonization include less accommodation of countries' individual preferences and abilities across countries to achieve the standards and the transaction costs of negotiation (43). The balance between benefits and costs will determine the incentives to harmonize any particular set of standards.

Harmonizing natural-environment-related product standards may be more complicated than it is for health and safety standards, because of countries' diverse natural resource and social conditions. Some environmental groups have in fact challenged harmonization efforts, arguing they could lead the world's trading nations (all of which have different incomes, environmental concerns, natural resource endowments, abilities to assimilate pollution, and desired levels of protection) to adopt the lowest standards possible for the sake of uniformity. Little systematic evidence is available to analyze the potential for so-called downward harmonization. Esty, citing the Montreal Protocol's effective upward harmonization for phasing out CFCs, argues that just the op-

[2] Specifically, article XX provides for two categories of general exceptions related to the environment. Article XX(b) allows exceptions for measures "necessary to protect human, animal or plant life and health," and article XX(g) permits exceptions for measures "relating to the conservation of exhaustible natural resources." Any measures implemented under the exceptions must not be "applied in a manner which would constitute a means of arbitrary or unjustifiable discrimination between countries where the same conditions prevail, or a disguised restriction on international trade" (48).

posite may occur (23). But the strength of upward harmonization forces will likely vary according to each specific environmental problem, and its potential benefits and costs.

New Product Standards Codes

The URA approved new codes for health and safety (called sanitary and phytosanitary, or S&P), and for technical barriers to trade (TBT), both of which address the question of product standards. The S&P code permits a country to impose trade measures to protect human, animal, or plant life or health from risks arising from the spread of pests and disease, and from additives or contaminants found in human food, beverages, or feedstuffs.[3] Key provisions of the new agreement base measures on scientific principles; use international standards as minimums where they exist (thus achieving partial harmonization); preserve federal, state, and local governments' rights to set their preferred level of risk protection and standards; state a preference for least-trade-restrictive measures; avoid disguised restrictions on trade; and provide opportunities for governments to demonstrate equivalency of protection from different measures (e.g., chemical versus nonchemical treatments) (48).

In negotiating the S&P agreement, the United States focused primarily on two food safety issues: preventing foreign governments from using false criteria to limit U.S. food exports, and ensuring that high U.S. food safety standards could be maintained (48). However, the new S&P code offers the opportunity for the 123 signatory countries to use product standards to protect their natural environments as well. Although the S&P code does not require signatories to adopt existing international standards as minimums, it improves matters by integrating more science, requiring risk assessments, and permitting higher national standards to avoid downward harmonization (67).

The TBT agreement essentially defines the process for distinguishing legitimate uses of product standards, technical regulations, and conformity assessment procedures from efforts to use them as disguised barriers to trade. "The TBT agreement addresses the development and application of mandatory and voluntary product standards which affect trade, and the procedures used to determine whether a particular product meets a standard" (48). For example, a measure requiring that foreign automobiles be equipped with air pollution emissions equipment falls under the TBT code. Possible agriculture-related issues falling under the TBT code include food-packaging requirements for waste disposal purposes, food product labeling, and definitions of the ingredients and processes used in certain food products, such as "fresh" milk.

The TBT agreement ensures a URA signatory country's rights to protect human health or safety, animal or plant life or health, and the environment as legitimate objectives. Only environmental measures related to product standards, however, are covered. The TBT agreement does not, therefore, cover most measures under the Clean Water Act, Clean Air Act, or similar legislation. Key provisions of the agreement include nondiscrimination against imports, measures that do not restrict trade more than necessary, and measures that are established in a more transparent way (48). The agreement also promotes the use of international standards where they exist, but preserves the right of countries to enforce more stringent standards at the federal, state, or local levels if they choose. The latter provision also addresses fears that use of international standards could cause downward harmonization of U.S. standards. (NAFTA also ensures that countries have the right to set higher standards and encourages upward harmonization.)

[3] "S&P measures include a wide range of health protection and food safety measures, such as: quarantine procedures; food processes and production methods; meat slaughter and inspection rules; and procedures for the approval of food additives or for the establishment of pesticide residue tolerances" (48).

The principal thrust of the new S&P and TBT codes to be administered under the WTO is to reduce unjustified restriction of trade by product standards. In that respect, they are directly applicable to agricultural trade, but concern food safety more than natural environment issues. A well-known case is the EU's action to ban imports of beef raised with the aid of growth hormones. The prospects for more disputes of this kind are considerable, given the URA provisions that reduce other forms of border protection. Data detailing such actions related to agriculture have not been assembled systematically for the nation or for its trading partners. The sole recourse for judging the extent and degree of potential trade restriction affecting agriculture—whether for food safety or for natural environment reasons—is extrapolation from isolated cases. A recent survey of agricultural crops from the southern United States found that existing product standards (and environmental regulations) do not significantly hinder the region's competitiveness in international markets, with the exception of the forthcoming methyl bromide ban discussed above (43).

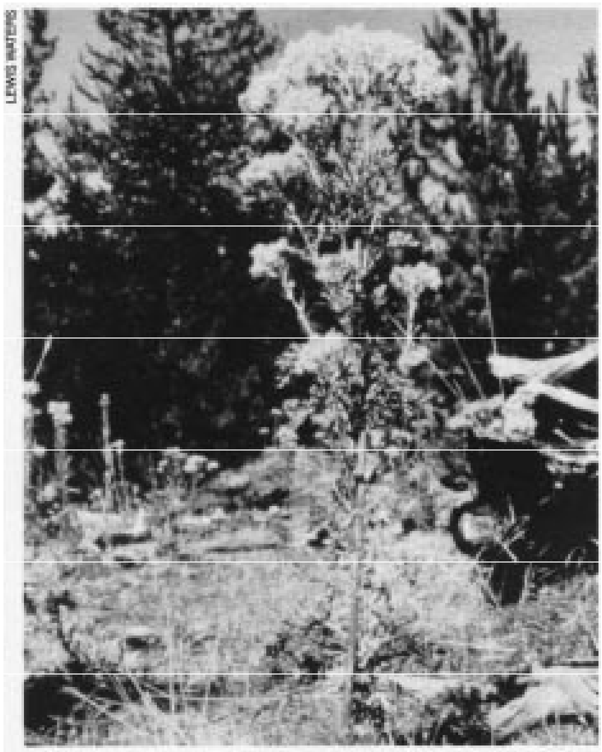
The new codes also provide a mechanism and rules to address environmental protection through product standards. The rules place the burden of proof on the country imposing trade measures for environmental purposes, thus forcing the country to defend its action as an article XX exception (23). The crucial test for environmental issues comes in whether WTO panels will approve product standards for environmental purposes, and under what conditions. Most cases relating to environmental matters that were brought before GATT panels in the past were either deemed not applicable to the exceptions code, or were not eligible for treatment as exceptions (78). There is consequently little evidence that the GATT processes have been an important venue for addressing trade-related environmental risks. Moreover, the panels that rule on such disputes have not included environmental scientists in the past, and have operated in closed sessions.

A review of key environment-related cases does not reveal a consistent set of principles for countries to use when planning to institute environmentally related product standards (23). As an illustration, an initial GATT dispute panel ruled that U.S. import restrictions against tuna caught by Mexican fishermen were illegal, because the environmental problem extended beyond U.S. borders. (See appendix II.) However, a subsequent dispute panel requested by the EU did not find such extraterritoriality a violation of the GATT rules (48). Perhaps the diversity of findings and lack of central principles should not be surprising, given the changing makeup of the panels and the different specifics of each case. Nonetheless, the United States plans to raise the scope of article XX exceptions related to the environment as a WTO agenda item (48). Clarifying the scope will help countries to makes decisions on domestic and international environmental issues. Also, the United States has urged the WTO to consider broader representation on environmental dispute panels, and to make the hearings and decisions more accessible to the public.

Harmful Nonindigenous Species

The role of nonindigenous species in U.S. agriculture has varied over time. Some introduced species, including soybeans, wheat, and cattle, have helped to create new agricultural industries, jobs, and wealth in the United States. But others have caused widespread and continuing damage. An estimated 50 to 75 percent of major U.S. weeds are nonindigenous and cause extensive damage to public and private lands; and 40 percent of the insect pests afflicting agriculture and forestry (including Russian wheat aphids, European and Asian Gypsy moths, and imported fire ants) are nonindigeous as well (28,66).

Also referred to as "exotic," "alien," "introduced," or "non-native" species, such harmful nonindigenous species (HNIS) have, in the past, been accidently or deliberately introduced into the United States, sometimes through trade. The invasions of knapweeds and cheatgrass/medusahead to western native rangelands and the introduction of melaleuca, a fast- growing tree to dry out south Florida wetlands, are examples. Future expansion



A number obnoxious weeds have been spread through trade causing commercial and environmental damages.

of agricultural trade will likely provide HNIS with new avenues into the United States (79). Controlling them at the border illustrates the product standard approach to dealing with possible environmental damages related to agriculture.

The costs of HNIS can be significant. From 1906 to 1991, the cumulative economic damage caused by 79 NIS organisms or species cases, less than 14 percent of the total invasions, was estimated at $97 billion (in 1991 dollars). HNIS agricultural weeds were not included. Estimates of future damages from 15 very harmful animal and plant diseases range between $66 billion and $134 billion (in 1991 dollars) (16). These estimates are, unfortunately, based on incomplete data, and almost certainly underestimate the actual costs because 1) in many cases, damage estimates were unavailable; 2) some commercial costs, such as private control expenses, were infrequently incorporated; and 3) the costs of certain losses to the environment, such as declines in recreational fishing, were not always quantified. According to the OTA assessment, much of the commercial damage is done to the agriculture and forestry industries. The environmental costs included declines in indigenous species and transformations of ecological communities and ecosystems. These environmental damages are significant, and extend beyond agriculture and forestry to national parks and other areas.

When the private parties or public agencies responsible for introducing HNIS are not responsible for paying such commercial and environmental damages, they will not be inclined to evaluate new introductions for the potential harm they might cause.[4] In those cases, the government may play a role in regulating trade, to prevent the introduction of HNIS. The S&P code is used for HNIS cases. The code sanctions the use of quarantines, for example, to minimize the chances that HNIS will enter a country. The United States has invoked this provision on a number of occasions: for example, to place restrictions on cut flowers from the Netherlands, and to ban seed potatoes from Canada and avocados from Mexico. Future actions, however, may be viewed as nothing more than protectionism, and open to challenge under WTO rules. GATT has rarely been used for such challenges in the past, though, because, as stipulated in article XX and elsewhere, it upholds a nation's right to establish its own rules and regulations regarding health and safety (which cover HNIS).

Preventing the introduction and spread of HNIS is an endeavor full of uncertainty and risk. Governments must not only establish criteria and procedures for controlling introductions, but also choose control strategies once HNIS have been introduced. Further, governments must determine acceptable levels of environmental and human risk, set risk thresholds above which formal decisionmaking approaches are invoked, and identify

[4] Some states require the deposit of funds to pay expenses in case nonindigenous species cause damage or require public action.

tradeoffs that may have undiscernible outcomes (79). Despite the considerable uncertainty, a review of selected economic studies shows that the benefits of controlling HNIS exceed the costs, usually by a large margin, with one exception (16). Early detection and eradication of HNIS can prevent much greater eradication or control costs after the pest has become widespread.

The key policy question relating to agricultural trade is whether to upgrade standards for screening imports. The OTA study cited above concludes that "perfect screening, detection, and control are technically impossible and will remain so for the foreseeable future" (79). Aiming for a "zero entry" standard would not only be prohibitively expensive, but unrealistic. Setting standards that are too high may unduly restrict trade, shut out helpful NIS, and lead other countries to retaliate by upgrading their own standards. However, setting product standards that are too lax exposes agriculture, other industries, and natural areas to the possibility of severe damage. A strategy of targeting agricultural crops and environmental systems at greatest risk from HNIS might, in this context, be the most effective way to deal with the problem.

As previously mentioned, the new URA product standard provisions stipulate that member countries must base their S&P measures on international standards (if they exist), and harmonization of standards is encouraged. The OTA assessment concludes that "complete harmonization of pest risk standards is probably not achievable, although agreeing on analytical processes may be" (79). Resolving scientifically complex issues of this sort through WTO panels will require expert environmental science input.

As the United States embarks on expanded trade relations with Mexico and Canada through NAFTA, new HNIS cases in North America will likely grow. For example, Mexico has recently changed its regulations affecting imported Canadian and U.S. Christmas trees-ostensibly to screen for gypsy moth infestations. However, it does not apparently have a clear scientific basis for doing so. Previous bilateral agreements have

Imports of containerized freight allow the introduction of harmful nonindigenous species to affect agriculture and the environment throughout the country instead of just U.S. porfs of entry

attempted to halt the transmission of foot and mouth disease between Mexico and the United States, as well as the invasion of the zebra mussel in the Great Lakes between Canada and the United States. Considerable resources have been devoted to coordinating pest prevention approaches with each country. NAFTA, in a vein similar to that of the URA, affirms members' rights to maintain "the level of protection of human, animal or plant life or health in the territory of a party that the party considers appropriate"; it requires that such measures be based on both scientific principles and risk assessment; it notes that in establishing their levels of protection, members "should take into account the objective of minimizing negative trade effects"; and it encourages harmonization of standards where appropriate, but discourages downward harmonization. It also made criteria for defending challenges to product standards more deferential to environmental measures and gave more access to environmental expertise for dispute panels than previous GATT or new WTO rules (21). The agreement does not directly address the problem of HNIS, but it does establish a Committee on Sanitary and Phytosanitary Measures that is charged with improving health and safety conditions throughout North America. A subcommittee devoted exclusively to HNIS might help to improve those conditions yet further.

DOMESTIC ENVIRONMENTAL EFFECTS OF AGRICULTURAL TRADE LIBERALIZATION AND EXPANSION

The potential environmental effects of changes in trade or trade policy have been described and categorized in myriad ways. Grossman and Krueger sort them into scale, product composition, and technique (i.e., production technology) categories. Runge (65) expands that set to include effects from general improvements in resource use causing less waste and from improved (environmental) policy. Building on these concepts, the OECD recommends national governments conduct a comprehensive review of the effects that trade measures or agreements might have on the environment. The review covers five categories (52):

1. *Structural effects*, which are associated with changes in the patterns of (micro or firm-level) economic activity (e.g., includes improved farm resource use);
2. *Technology effects*, which are associated with changes in physical, biological, or other processes or production methods;
3. *Scale effects*, which are associated with the overall level of economic activity induced by changes in trade flows and the implications for environmental pollution and cleanup;
4. *Regulatory effects*, which are associated with legal or policy effects of a trade measure or agreement on environmental regulations, standards, subsidies, or other programs; and
5. *Product effects*, which are associated with the export or import (but not production) of specific products that can harm or improve environmental quality.

The following analysis uses the OECD terms to examine the effects that expanded and liberalized agricultural trade might have on the U.S. environment. The structural and technology categories are combined to capture the shifts in crops and livestock enterprises with their closely tied production technologies. Major product effects are not expected to be significant (save for the effect of HNIS, which has already been detailed), and are not discussed.

Structural and Technology Effects

Farmers' decisions about what kinds of crops to grow; where to grow them; and how to combine land, water, and other resources to produce their products all have environmental consequences. For example, in response to larger markets overseas, a farmer may use more land to grow certain crops, or use land more intensively—that is, by tilling more pasture or prairie, or applying more fertilizers or pesticides. Conversely, farmers who have been protected from foreign competition by tariffs, quotas, or other trade barriers may change the kinds of crops they plant and the way they grow them if, as a result of trade liberalization, they are faced with more foreign competition. Depending on how the land is used after the trade restrictions are removed, stress on the environment could increase or decrease.

The environmental effects of a farmer's decisions will depend on what combination of choices he or she makes with regard to particular resources. For instance, the amount of water runoff or chemical leaching that results from producing corn depends on whether the corn is planted on steep uplands or on sandy, permeable lowland soils that overlie shallow groundwater susceptible to chemical leaching. Some environmental consequences, such as erosion runoff and muddy streams, are obvious locally, but cannot be easily traced further downstream. Others, such as groundwater contamination or wildlife effects from habitat changes, may not be completely revealed for some time.

The shifts in agricultural trade caused by NAFTA and the URA will determine the size, location, and nature of such new strains on the environment. The U.S. Department of Agriculture (USDA) estimates that expected increases in production related to the agreements are relatively small, ranging from a low of about 1.5 percent of acres planted in major crops in the year 2000 to a high of approximately 3 percent in 2005 (85).

Crop-specific estimates indicate that wheat acreage increases by 5 to 8 percent, coarse grain acreage by 1 to 2 percent, soybean acreage by 3 to 4 percent, and cotton acreage by 2 to 5 percent (compared with what the situation would be without the agreements). Land that currently remains "idle" under government supply control programs would likely meet the additional export demands in 2000 and probably up to 2005, although it would mean some increase in erosion and other environmental damage. Another set of estimates by the International Trade Commission (ITC) shows smaller net production increases. (90) (See chapter 3.).

Looking at these overall changes is, however, merely a starting point. To project the possible environmental effects of expanding agricultural trade, it is necessary to examine specific changes in production and in the means of production (i.e., production technologies). OTA contracted with researchers at Texas A&M University to analyze what regional shifts in agricultural production would occur, and what possible environmental stresses would result, from projections of expanded agricultural trade under NAFTA and the URA (44). The analysis assumed that the current commodity programs continued with Acreage Reduction Program (ARP) levels at 1990 levels of about 27 million acres; that commodity program base flexibility remained at 15 percent of enrolled commodity program acres; and that 10 million acres of the most highly erodible land in the Conservation Reserve Program (CRP) were kept out of production.

Estimates show that overall cropland use rises less than 1 percent by the year 2000 under the higher USDA export projections with the URA and NAFTA. The enlarged cropland base from CRP lands returning to production, coupled with average technology improvements, nearly offset the rise in net export demand. None of the major environmental measures showed changes of more than 1 percent and some even declined (for instance, water use and phosphorus). Overall, the combination of changes in crops and technology, when spread across all farmland, was not estimated to cause significant damage to, or for that matter improvement in, the environment. The low projected erosion rates result from a combination of cropland returning to production under conservation tillage techniques; the retention of the most erosive lands in the CRP; wheat production technology, which causes less erosion than the production technologies used for some of the crops it is projected to replace (59); and other changes. The larger agricultural export estimates for 2005 would, it is assumed, have larger effects on the nation and various regions, but would probably not increase any environmental measures by more than 3 percent. These findings are consistent with general assessments of the environmental effects of trade and trade liberalization (51) and for other countries (e.g., 61).

Commodity Program Influences

For the OTA analysis conducted by Texas A&M researchers, it was assumed that agricultural commodity programs would operate as they do now because the URA did not mandate change for the most part. The URA establishes a ceiling and reduction schedule for total domestic agricultural support (which the United States has already met), exempts deficiency payments from the ceiling and reduction calculations, and preserves the United States' authority to make commodity specific payments and acreage set-asides.

Even though the URA did not effectively reform commodity programs, budget pressures and other forces will likely lead to further changes in them. Assuming that there will be additional reform, what type of environmental effects might follow? Basically, how the crops, livestock, and their production technologies spread across the natural resource base determine what happens to the environment (5). Much depends on the precise nature of any reform—for example, whether income and price supports are eliminated or just "decoupled" from particular crops and production levels, and whether land set-asides continue. Also pertinent are assumptions about how competing exporters may reform their programs, and how those reforms might affect world markets and price levels. For example, if all WTO countries simultaneously removed subsidies that encourage domestic overproduction, world prices would rise significantly in the short term as global supplies fell. In the longer term, other sources of supply (e.g., developing countries) could appear and make markets stable again—at prices that would be higher than what they are now, but lower than what they would be during the initial short-run surge.

Investigations of the environmental effects of reforming agricultural support programs have taken place on the international, national, and regional levels. It is important to consider that the science and data to describe the production-environment relationships at ecosystem levels simply do not exist, and so precise calculations are impossible to make.[5] Nonetheless, results from all levels provide largely consistent and corroborative results. (See appendix I.) Generally, multilateral reform of commodity programs—by lowering or decoupling price subsidies and by reducing land set-asides—would likely decrease chemical pollution and many other stresses on domestic environmental resources, such as water withdrawals for irrigation. Although the analyses focus on reforms in prior years, the findings are still relevant because the basic structure of U.S. commodity programs has remained unchanged. Kuch and Reichelderfer (37) note that the potential environmental effects of reform will likely be limited in industrialized countries. Moreover, agricultural program payment levels in industrialized countries have been decreasing, which implies that less environmental change will occur if support is withdrawn because the programs are exerting less effect on production. (See chapter 6.) Kuch and Reichelderfer stress that the extent of environmental impacts depends largely on the kinds of environmental programs in place after agricultural programs are reformed. A separate assessment arrives at the same conclusion (50).

Because current studies of program reform do not fully describe long-term adjustments, overall estimates of environmental improvement are probably lower than they need be. (Flexible, cost-effective environmental programs might, for instance, induce farmers to change their production methods, and so further reduce impacts on the environment.) (See chapter 4.) Some analyses have indeed indicated that pollution could be reduced more over the longer term (1). The overall implications for global environmental conditions are not clear, but are likely to be positive, because there will probably be less chemical use in developed countries, and some livestock production will move to developing countries (thus reducing higher concentrations of livestock in the developed countries).[6] However, that positive outcome depends on the developing countries' abilities to translate increased income from trade gains into more effective environmental protection.[7] At least one negative domestic environmental effect is forecast: erosion rises as land that had been idle under the ARP or CRP is planted.

Import Liberalization

NAFTA and the URA also reduce some U.S. trade barriers against foreign agricultural products, thus

[5] Fairly complete data on the production of crops and livestock and the use of fertilizers, energy, and other inputs by major U.S. regions are recorded each year by USDA, which separately collects data describing the condition of natural resources used in agriculture (82, 87). However, data that describe existing agricultural production technologies and crops and how they relate to the environment are not collected on a comprehensive basis, perhaps owing to the size and cost of the task. Without that information, unfortunately, precise estimates of the environmental effects of expanding agricultural trade across ecosystems are not possible.

[6] Anderson (2) explains that production patterns and technologies in developing countries rely relatively more on extensive land use for growing crops and livestock, and less on increased fertilizers and pesticides, than in developed countries. As a result, production shifts under policy reform would be expected to put relatively more pressure on the land resources in developing countries and less on chemical use in developed countries.

[7] There is doubt that developing countries can design and implement effective environmental programs to ameliorate significant problems in the event of full agricultural trade liberalization, especially in the short term (42).

increasing market access for imports. Currently, several kinds of U.S. agricultural products are still protected from foreign competition, including sugar, dairy products, and peanuts. Generally, in such cases, domestic production (and land use) expands to fill domestic demand, and producers receive more for their products than they could if they faced unsubsidized foreign competition. If protected sectors are not subject to effective environmental programs, they may use more "unpriced" environmental resources than unprotected sectors do, simply because they are larger. But protected sectors earn high "pure" profits (profits in excess of all production costs) and can invest in developing technologies to retain their profit position.[8] That is, if they are required to meet certain environmental standards, they may do it at a lower cost than they could when faced with more competition.

Box 5-1 explains how the south Florida sugar cane industry, which has benefited for decades from protectionist policies, may be able to devel-

BOX 5-1: Agricultural Production and Environmental Linkages in South Florida—Sugar's Connection to the Everglades*

The environmental problems facing the Florida's Kissimmee-Okeechobee-Everglades watershed (69) center on three major issues:

1. *Water Quantity, Distribution, and Timing* —How much water goes where, when, and how is it distributed?
2. *Water Quality* —How "clean" should the water be, and what is the best way to make it clean?
3. *Cost* —Who pays the bill?

As a result of the current water management system, the remaining Everglades natural areas receive about half as much water, and about 200 tons more phosphorus, than they originally did (69) The drainage and flood control system constructed to aid urban, agricultural, and other developments has not only heavily contributed to present environmental conditions, but has also defined how land will be used. Agriculture has taken over a large amount of the drained land (about a half million acres of former custard apple swamp and marsh) As a result, agriculture will figure prominently in any solution to the area's environmental problems

Since 1988, Florida, working with federal agencies, has developed an environmental Improvement plan for the Everglades Passed in 1994, the Everglades Forever Act (EFA) defines a plan to

> begin restoring a significant portion of the remaining two-million-acre Everglades ecosystem by reducing the amount of phosphorus-enriched agricultural stormwater entering the system, improving the quantity and distribution of freshwater, and setting deadlines to achieve these objectives (70).

EFA also creates funding mechanisms that address all three of the issues raised above In addition, it establishes mechanisms to control harmful nonindigenous species (HNIS), even though problems with HNIS are not linked directly to Everglades agriculture.

For agriculture specifically, EFA has several important implications More than 40,000 acres of man-made filtering wetlands, called stormwater treatment areas (STAs), will be created in the Everglades Agricultural Area (EAA). The STAs are designed to reduce the amount of phosphorus in stormwater runoff before the stormwater enters Everglades and Water Conservation Areas, and to improve the Everglades hydroperiod. Specifically, the interim water quality target is 50 parts of phosphorus per billion,

(continued)

[8]Whether allowing a sector to earn pure profits (and essentially granting it associated research and development advantages) reflects the most appropriate use of those funds remains an open public policy question.

BOX 5-1 (Cont'd.): Agricultural Production and Environmental Linkages in South Florida—Sugar's Connection to the Everglades*

and the amount of water flow is estimated to increase by 28 percent and lengthen the duration of flow. After the interim measures have been implemented, a scientific process will be used to determine the final targets for water quality

The question of who pays how much is also addressed Sugar and vegetable growers must pay about $25 per acre per year in the form of an "agricultural privilege tax" over the next 20 years to construct the STAs If further pollution control measures are required to reach the final targets, the cost could rise to $35 per acre from 2006 to 2113 under assumed conditions (60) Vegetable growers are not subject to the potential Increase. When the STAs are completed, EAA growers will pay $10 per acre for operation and maintenance costs, while farmers operating outside the EAA but in the area will pay about $2 per acre Supplemental funding will be collected from public sources such as highway tolls

EFA also requires all farmers in the area to develop and implement innovative best management practices (BMPs) to reduce all pollutants flowing into runoff waters Since these BMPs are not in place, the true costs are not known. Current estimates are $1 per acre to achieve the minimum 25-percent reduction in phosphorus emissions (which will obviate the need for the $10 tax Increase) The estimates rise to about $25 per acre for a 45-percent reduction (91) Florida sugar growers were estimated to have received an average of about $230 of pure economic profit or rent per acre from 1986 to 1990 (69) Future profits are projected to decline slightly from the $230 level The total tax and BMP charge would reduce pure profits to about $200 per year for the 20-year construction period Converting the taxes and BMP costs to a per- pound of sugar basis (based on 1986-90 yields) implies that the charges constitute a O 5 cent increase per pound, or just over 2 percent of average price of sugar over the same period.

These figures reveal that, on the whole, sugar growers have ample capacity to absorb the environmental charges, Gwen their large pure profits, sugar growers have resources to develop innovative technology to reduce the BMP costs even further, assuming that flexible environmental policies prevail Sugar production appears to be an economic fact of life under current market conditions and given the relatively low-cost south Florida production technology---despite the fact that large federal subsidies were used to develop that efficient technology Trade liberalization will not likely displace Florida's sugar industry, although it may reduce its size.

Environmental restoration of the Everglades must proceed with these realities in mind What should be the sugar industry's role in that restoration process? Under the EFA environmental targets, the average costs imposed on sugar producers take only a small portion of their pure economic profit Achieving environmental restoration beyond the current EFA targets—by reducing the area of sugar production—would be expensive in two respects. First, taking land out of production will be costly as evidenced by the large pure profits and land values. However, removing the sugar program protection will lower the land values and therefore lower land acquisition costs Second, unless some mechanism can be found to allow the lands to revert to natural conditions, alternative land uses may do more environmental damage. Data often reveal that using land for urban and industrial purposes generates much greater pollution per unit area, Assuming that the elimination of domestic sugar subsidies releases some land from sugar production, it does not follow that environmental conditions will Improve automatically, That determination depends on how the land is ultimately used and the environmental rules under which it will be used,

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* Material in this section was drawn from a contractor report prepared for OTA by Rand Snell and William Boggess "Water,Agricultural, and Environmental Policy Issues in South Florida, " June 1994

op cost-effective technologies to meet high environmental standards (69).[9] Also explained is the notion that the ultimate environmental effects of any land leaving sugar production depends on the applicable environmental policies. In south Florida, either vegetable farms or residential developments may do more harm than existing sugar production (69). It is crucial to note that these findings do not support the use of protectionism to improve the environment. Indeed, open competition between domestic and foreign producers is conducive to achieving long-run economic and environmental benefits. However, the case study indicates how difficult it can be to devise effective environmental policies when dealing with an historically and economically anomalous situation. If Florida's sugar growers had always faced competition, then effective environmental programs, and public research targeted to complementary technologies, would likely have benefited society more than the growers' current efforts at environmental cleanup do. The messages from chapter 4 and from this case are the same: the nature of agroenvironmental management programs is the most critical element to determining environmental quality.

Overall, import liberalization resulting from the URA will probably exert a limited effect in the near-term due to ambiguous rules governing the process (67). Some measures were included to guard against foot-dragging by importing countries reluctant to open their markets, however, there are no guarantees of improved market access (73). Certain areas where protected crops dominate and significantly affect the environment may undergo considerable change over the longer-term as pressure for further liberalization grows. Again, it is obvious that emphasis must be placed on identifying regional pockets where the environment will be greatly stressed, and on targeting these areas with appropriate agroenvironmental programs.

Regulatory Effects

The nature of the environmental effects that result from expanded and liberalized agricultural trade depends not only on the magnitude and types of changes in production, but also on domestic environmental policy—more specifically, on the way governments manage or change their environmental programs due to the trade measure or agreement.

The possible return of idled acres to production demonstrates once more that domestic environmental programs ultimately dictate the consequences of trade expansion. The basic problem is that comprehensive, effective policies do not cover areas facing significant risks of environmental damage. Can current domestic environmental programs effectively treat any pockets of stress or other large problems, such as invasive HNIS, without significantly interfering with trade flows? Cost-effective management programs can induce technological changes over time, such as improved conservation tillage practices, better soil

[9] Popular belief dictates that protected (and less than fully competitive) industries are likely to be less vigorous in reducing cost than other industries. The Florida sugar industry's declining production and processing cost structure do not support that notion. The incentive to continue earning, and even to enlarge, their pure economic profits, coupled with the large capital base afforded by price protection, has evidently led to technological innovation and production cost decreases through economies of size (69). In this "trustified capitalism" formulation, the pure economic profits are necessary to allow the firms to invest in research and development that will lead to innovation. Industries comprising many competitive firms do not enjoy the necessary capital base or profit-making opportunities to permit such dynamic technological innovations, although they have strong incentives to adopt existing technological improvements. If accurate, this view of technological innovation has two implications for the issues at hand. First, profit-producing trade restrictions that protect certain industries (such as sugar) may allow them to conduct kinds of research and development that may not be considered a priority in other industries. Second, if the industries remain protected and retain their customary profit levels, they will be able to meet environmental requirements at lower costs through their technological innovations. A related observation is that more-competitive industries will not be as likely to generate technological innovation in meeting environmental standards, because they cannot earn pure profits. In the latter case, if competitive markets remain an overriding public goal, the rationale for public research and development assistance directly follows (22).

testing that can reduce fertilizer application rates, and increased use of biological pest controls to reduce applications of chemical pesticide applications. These changes can simultaneously lessen environmental damage and reduce the estimated cost of environmental compliance, thus helping trade to remain competitive.

How do existing programs measure up when all the environmental benefits and costs are considered? Two criteria may be used. First, are the standards or levels for environmental quality too high or too low? On this matter, analysts can provide information about the likely environmental, economic, and social benefits and costs of various standards—but the public, through Congress, must ultimately decide what the appropriate standards are. Second, are existing mechanisms adequate to ensure that farmers and consumers fully pay environmental costs and receive compensation for providing environmental benefits? Environmental programs come in a variety of forms: production or emissions controls, technology requirements, purchase of land or water rights, and subsidies and taxes. The basic question is, which mechanism achieves the environmental objective, in the short term and long run, at the lowest possible cost?

The United States has nearly 60 years of experience in applying conservation and environmental programs to agriculture. Chapter 4 reviewed programs that deal with soil conservation, water quality, wetlands protection, pesticide registration, and other issues. The principal conclusions of the review were:

- traditional voluntary education and technical assistance efforts have not produced widespread and enduring change;
- subsidy-based programs have produced benefits, but for the most part have not been targeted for maximum opportunity to yield benefits;
- compliance programs do not match environmental priorities and are vulnerable to budget cuts;
- regulatory efforts have been spotty and have not stimulated timely technology innovation; and
- research and development efforts to understand agroenvironmental priorities, and to develop technologies that produce complementary production and environmental effects, have been insufficiently funded.

The recurrent themes of insufficient targeting and incomplete coverage suggest that the agroenvironmental programs currently in place will not cope well with any trade-induced pockets of environmental stress or invasions of HNIS. Moreover, those shortcomings, when considered along with insufficient science and technology R&D, do not promise a long-run complementary path for agricultural trade and the environment.

Scale Effects

As mentioned previously, increases in agricultural production resulting from NAFTA and the URA are not expected to exert significant stress on the environment. Indeed, as increased agricultural trade raises incomes, the environment could benefit. A growing body of evidence indicates that as per-capita income levels increase, environmental pollution decreases, although the relationship is not fully understood (32,40,41).

One of the key determinants of this relationship is the rising demand for environmental quality as income levels increase. However, recent reviews of evidence on this relationship suggest that the rise in demand may not be as large as thought previously (36). Changes in the composition and technology of production also play important roles. If this relationship applies to agriculture, increased income from trade growth could improve agroenvironmental conditions.

The hypothesized effects pertain to expanding trade under NAFTA and GATT. As liberalized trade places more pressure on environmental resources and raises incomes, stronger environmental management programs will emerge. The resulting effects on the environment will, accordingly, depend on the balance between the two forces and the timing of problems and management programs. Given that expanded trade will not change either U.S. production patterns or income dramatically (estimated at less than 0.2

percent of GDP) over the next five years, the near-term effect is likely to be small (67). In the long run, income growth from general development, including expanded trade, will spur improvement in the national environment, but only gradually. The nature of that improvement will be defined by incentives for technology development and behavior change encouraged by environmental programs. Whether the improvement extends to global environmental resources, such as plant and animal biodiversity, is unclear because of the difficulty of cooperatively managing those resources.

TRADE MEASURES TO ACHIEVE INTERNATIONAL ENVIRONMENTAL OBJECTIVES

Some of the transboundary or global environmental problems stemming from increased agricultural trade affect U.S. interests. Pesticides may contaminate air and rivers that cross into U.S. territory; losses of plant and animal species may reduce the gene pool available for domestic production and ecological functions. In such cases, national environmental programs will not be enough to ensure that the problems are addressed (68). Regional or international mechanisms, such as multilateral environmental measures tied to trade, stand a better chance of success. So far, two trade-related approaches have been used. The first approach has been to work through trade agreements to accomplish environmental goals; the second, to use trade measures within international environmental agreements.

Environmental Provisions Related to Trade Agreements

NAFTA presented the first opportunity to use a trade liberalization agreement for advancing regional environmental objectives. Mexico suffers from severe environmental problems—especially along its border with the United States, where most of the country's foreign-owned "maquiladora" plants are located. NAFTA opponents argued that if the agreement were implemented, Mexico could become a "pollution haven" for industries that did not wish to pay the costs of complying with U.S. or Canadian environmental laws. Such arguments proved persuasive, even though the Mexican and U.S. governments had earlier concluded an integrated border environmental plan to clean up the region.

Ultimately, the NAFTA negotiators were compelled to include several unprecedented "environmental" provisions in the body of the agreement, making it the world's first "green" trade pact (21). The NAFTA text states, for example, that the provisions of certain international environmental agreements (e.g., the Basel Convention on the Control of Transboundary Movements of Hazardous Waste, and the Montreal Protocol on Substances that Deplete the Ozone Layer) generally take precedence over NAFTA provisions. NAFTA members are allowed to set their own levels of environmental protection, within certain parameters. NAFTA further exhorts members to enforce their own environmental laws, and to refrain from attempting to attract foreign investment by lowering, or failing to enforce, environmental standards. It also allows members to impose some environment-related performance requirements on foreign investors, and to refrain from granting patents for inventions that might harm the environment.

Public pressure also led to the addition, in August 1993, of a NAFTA environmental side agreement, which deals more specifically with transboundary environmental concerns. The North American Agreement on Environmental Cooperation (NAAEC) lays the groundwork for addressing regional environmental issues through a tripartite Commission for Environmental Cooperation (CEC), funded by the three NAFTA members. The CEC's mission is to monitor how NAFTA's environmental provisions are implemented, work toward harmonizing and raising North American environmental standards, develop ways to enhance the North American environment, function as a clearinghouse for NAFTA-related environmental issues, and review cases of members' alleged nonenforcement. Cases may go to an arbitral panel under the CEC if a NAFTA party allegedly engages in a "persistent pattern of failure" to enforce a particular environmental law or laws. Thus, the CEC is geared not only to regional environmental improvement, but also to leveling the trade playing field by punishing lax enforcement of domestic environmental laws—which, theoretically, might affect industries' location and investment decisions. Finally, NAAEC commits countries to provide for public participation in domestic environmental policymaking and enforcement (21).

An agreement such as NAAEC is unprecedented in the history of trade negotiation and represents a landmark achievement in linking regional environmental and trade issues. Nonetheless, it is difficult to determine whether NAAEC will be a particularly useful institution for addressing transboundary environmental issues, for three key reasons:

- First, the NAAEC provisions significantly restrict the kinds of nonenforcement actions that may be challenged. Under NAAEC, only a "persistent pattern" of nonenforcement (which is defined in the text only as "a sustained or recurring course of action or inaction") may be challenged, and a member "has not failed to effectively enforce its environmental law" if its action "results from bone fide decisions to allocate resources to enforcement in respect of other environmental matters determined to have higher priorities." The agreement also stipulates that sanctions against a NAFTA member that does not enforce its own environmental laws must take into account "the level of enforcement that could reasonably be expected of a party given its resource constraints," and that NAFTA members may withhold information on a case from the CEC under certain circumstances.
- Second, as critics such as Charnovitz (15) argue, the CEC has no enforcement power beyond allowing one member to institute trade sanctions against another. Such action would be taken only after a significant amount of time had elapsed and significant sums had been spent on litigation. However, the CEC can conduct fact finding and publish the results in attempts to use adverse publicity to instigate pollution cleanup.
- Third, and crucially, the NAAEC agenda conceptually treats transboundary and domestic environmental problems as equal concerns. As a consequence of casting their environmental net so widely, it is possible that the NAAEC member states may not be able to focus the attention they otherwise could on pressing transboundary problems. As the Environmental Protection Agency (EPA), other agencies, and countless experts have confirmed, the border region between the United States and Mexico suffers from serious pollution problems (89), which may be exacerbated to some extent by NAFTA. Such problems as the highly polluted New River, which flows from the industrialized and overcrowded Mexican city of Mexicali through California's agricultural Imperial Valley, may be one of the most polluted rivers in the world, with problems yet to be fully addressed (38). However, in one of the first cooperative efforts under NAFTA, the U.S. Environmental Protection Agency (EPA) and the Mexican Secretariat for Social Development have cooperatively made the reduction of New River pollution a high priority on both sides of the border (84). Several other initial activities between the United States and Mexico suggest a principal focus on border-related problems, so for the moment the potential for spreading efforts too broadly appears small (84). The countries are also cooperating on studying similar agroenvironmental problems (e.g., rangeland erosion), and possible transfer of technologies (81).

A more direct approach to the problem of the border region, and by extension to transboundary environmental problems related to trade, has been through bilateral agreements between the United States and Mexico, and through the recent creation, in NAFTA's implementing legislation, of the North American Development Bank (NAD Bank) and the Border Environment Cooperation Commission (BECC). As mentioned above, the United States and Mexico released an Integrated

Environmental Plan for the Mexican-U.S. Border Region in February, 1992, which aims to attack border pollution problems through joint efforts to promote training, education, and planning programs, and to better enforce the nations' environmental laws. The border plan has been criticized as vague, without commitments to specific projects (34), and its allocation of $200 million for 1994 from the United States falls strikingly short of the billions of dollars that some experts deem necessary to improve sewage systems, water pollution, and air pollution in the area. For example, Hufbauer and Schott (34) recommend that $5 billion be dedicated to the border region over five years.

NAD Bank's initial purpose is to make loans for infrastructure projects that will ensure cleaner water, adequate wastewater treatment, and adequate solid waste disposal in the border region.[10] Located in San Antonio, Texas, and capitalized by the governments of the United States and Mexico, NAD Bank will make some $2 billion to $3 billion in guarantees and loans available for these projects. For 1995, $56 million was appropriated by Congress. The bank will work cooperatively with BECC, which will help locate, design, assess the environmental impacts of, and approve the projects in communities on both sides of the border. As these institutions are so new, it is not possible to gauge their efficacy, although the U.S. House Committee on Banking, Finance, and Urban Affairs found that the NAD Bank proposal was "seriously defective" because the bank's financial mechanisms were potentially unworkable (77).

One area that might test the efficieny of NAAEC and NAD Bank lies along the southwest Texas and Mexican borders, where trade liberalization will expand industrial growth. Box 5-2 explains some of the cross-border problems of the Lower Rio Grande Valley and the current difficulties in addressing the issues. Interestingly, there is little

Increased trade and manufacturing activity along the U. S.-Mexican border causes increased pressure on transboundary environmental resources,' here an effluent from a Mexican cottage industry drains into the Rio Grande River which U.S. agriculture draws on for irrigation.

chance that gradual reduction of trade barriers here will induce substantial agroenvironmental problems. Rather, concerns center on the negative effects that nonagricultural growth could have on agriculture, especially with regard to transboundary flows of polluted water.

Although it in no way rivals NAFTA as a "green" trade pact, the URA has new "environmental" provisions as well. The text sets the environmental stage for the World Trade Organization (WTO). Explicit mention of the need to address environmental issues and pursue sustainable development appears in the WTO preamble (49). Specific environmental provisions include the

10 An obvious question is why subsidized loans may be acceptable tO use for transboundary pollution but not for national environmental problems under the OECD principles. The answer maybe one of necessity: subsidies are necessary to induce transboundary cooperation because multilateral regulations requiring cooperation do not exist and collaboration is costly.

BOX 5-2: Transboundary Environmental Linkages: The Lower Rio Grande Valley*

Adjoining the Mexican border and its maquiladora plants, the Lower Rio Grande Valley (LRGV) of Texas lies at the heart of expanding trade between Mexico and the United States The LRGV is replete with valuable environmental resources, such as several rare and endangered wildlife species The Rio Grande River is an integral resource for the region, but its quality deteriorates as it approaches populated areas downstream. Air quality is also a concern, as urban sprawl, Industry, and transportation expand in response to the region's growth, Many of the LRGV's environmental resources are shared across the border and so require multinational approaches for effective management.

Surface and groundwater quality are two transboundary challenges Because the river and its reservoirs provide and receive U.S. and Mexican municipal, industrial, and agricultural waters, it is a critical resource Above the cities of McAllen and Reynosa, Rio Grande River water quality is primarily influenced by releases from the Falcon Reservoir (on the western edge of the LRGV) and is excellent (72) But as the river continues southeast, it becomes increasingly degraded Below the two cities, for example, the river does not meet quality standards for swimming due to elevated fecal conform bacteria levels, primarily the result of Inadequate treatment of Mexican municipal sewage. Five Mexican cities—Juarez, Cludad Acuna, Piedras Negras, Nuevo Laredo, and Reynosa---dump 60 million gallons of raw or partially treated sewage into the Rio Grande each day (20), Untreated sewage IS dumped into the river by colonias (unincorporated rural subdivisions) on both sides of the Rio Grande. Fecal conform levels below Nuevo Laredo are 33 times greater than the allowable safe Iimits. Further, phosphorus and chlorophyll a levels in sediment are concerns as is DDE (a derivative of DDT during degradation) toward the river's mouth

These river water quality problems are Iinked to agriculture in two ways. First, irrigation water for fresh vegetables and other crops is taken from the degraded portion, and may cause problems for food safety Second, agricultural nutrient and pesticide effluents can move to the river from Mexican farms Pesticide and fertilizer use have generally Increased over the past two decades, with potential for runoff to surface waters and leaching to groundwaters (88). Some researchers believe that agricultural pesticides may be a source of birth defects along the U S -Mexico border (1 1). However, a recent U.S. Environmental Protection Agency (EPA) study did not find sufficient pesticide exposures near Brownsville to warrant health concerns. Within Texas, there are also surface water quality problems in the Arroyo Colorado, which flows from Hildago county to the Laguna Madre on the Gulf Coast: principally elevated levels of phosphorus, ammonia, nitrate, chlorophyll a, and fecal coliform, plus concerns about manganese, selenium, DDE, and PCBs. The Texas Natural Resource Conservation Commission attributes most of the problems to municipal effluents.

Groundwater in the LRGV ranges in depth from 180 feet in the west to 20 feet or less near the coast Generally, groundwater quality problems stem from excess sodium chloride, bicarbonate, and sulfate, most of which occur naturally and are not directly attributable to agricultural activities, The Texas Water Commission reports that some groundwaters are vulnerable to pesticide leaching, but they are generally too salty for Irrigation or human consumption, For a 17-county area of southern Texas, where there are high-growth centers (for instance, McAllen, Eagle Pass, and Laredo), the groundwater levels are declining due to pumping with Iittle systematic planning and intervention from either or both countries, In this larger region, there are some aquifers at risk, At present, Texas and Mexico have no history of cooperation to manage transboundary aquifers, With Increased economic growth, the potential for further groundwater mining for municipal and Industrial purposes will increase, and allocation problems wilI Iikely grow.

There are other Important transborder environmental issues, Growth in fresh fruit and vegetable imports from Mexico, along with an Increasingly diverse product mix, will place additional demands on

BOX 5-2 (Cont'd.): Transboundary Environmental Linkages: The Lower Rio Grande Valley*

U.S. Food and Drug Administration resources to monitor fresh produce as it crosses the border (47) Available Information reveals a significant gap between U.S. and Mexican pesticide standards regarding their impacts on human health (63). Newman notes that Mexican regulations on pesticide use are Increasingly similar to those in the United States, but questions about relative enforcement are unanswered Another effect stems from Increased air pollution accompanying greater motor vehicle transport of commerce (and toxic spill potential), which can negatively affect crop yields, human health, and aesthetics Mexico's current vehicle smog emission standards are less restrictive than those of the United States (63) Finally, managing wildlife habitat, some for endangered species, in the face of expanding populations poses a considerable multilateral challenge

Environmental Program Responses

Existing institutions in both countries do not adequately address environmental losses or exploit potential environmental gains (e g , wildlife habitat). Most of the region's environmental problems stem from the absence of effective mechanisms, markets, public policies, or lack of enforcement of policies, to balance benefits and costs or risks An assessment of the existing environmental institutions shows a mixed picture of policy effectiveness In some cases, the policies may unnecessarily constrain competitiveness. In short, the LRGV region appears to suffer from incomplete environmental policy coverage on both sides of the border, as well as for managing critical transnational resources

Effluents coming from Mexican sources are subject to Mexico's General Ecology Law (1988) and Implementing institutions. Mexico has taken several steps forward in environmental management during the past decade. Mexico's poor economic state has, however, hampered the implementation and enforcement of more stringent environmental standards Additional resources for monitoring, technical assistance, and enforcement wilI be necessary to control water pollution effluent from Mexican cities as they grow. A similar prognosis applies to air quality and wildlife habitat protection

Effectively addressing these issues wilI require cooperation between agriculture and other sectors, between domestic government agencies, and most important, between Mexico and the United States Three courses of action warrant consideration (62) First, public officials could evaluate the harmonization of environmental standards between the United States and Mexico, including those pertaining to agricultural production and lands. Following NAFTA provisions, the harmonization process should not lower the level of protection in either country, and preferably harmonize to the higher level in either country Second, environmental problems stemming from public entities such as wastewater treatment facilities could be attacked by creating innovative funding mechanisms. Most of the border communities are not high-income areas and wilI require financial assistance to eventually meet existing water and air quality standards. Third, programs could be developed to assist public agencies in both countries on environmental monitoring and enforcement activities. Technical training on instrumentation, inspection protocols, and data monitoring and interpretation should be high-priority activities. Coordination across the border is key The translational Institutions created as part of the NAFTA process, such as the North American Development Bank and the Border Environment Cooperation Commission, have the potential to help in this regard, but are only skeletons at this point Their potential effectiveness wilI depend largely on the vigor with which private and public parties infuse them with energy, resources, and wise policy choices (7)

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*Material in this section was drawn from a contractor report, "Agricultural Trade and the Environment Potential Impacts on the Lower RIO Grande Valley of Texas," by C.P. Rosson Ill, A. Pagano, E.B. Summerour II, L.L. Jones, R D Lacewell, T. Ozuna, A. Wise, M J Taylor, and S.M. Masud of the Department of Agricultural Economics, Texas A&M University, July 1994 new S&P and TBT agreements already discussed in this chapter, permission for selected environmental subsidies, and a dispute settlement procedure that is more open to public scrutiny (48). In addition, and like NAFTA, the URA text allows panels that are convened to settle trade disputes to seek expert scientific and technical advice regarding environmental matters. Finally, the WTO established a permanent committee on trade and the environment with broad terms of reference and a two-year period for reporting recommendations.

The inconsistency of the URA subsidy provisions with the polluter-pays principle (PPP) merits further comment. Governments are generally permitted to subsidize efforts that "promote adaptation of existing facilities to new environmental requirements imposed by law." Such subsidies must be one-time measures and are limited to 20 percent of the cost of adaptation. But agriculture is treated differently: the agreement permits the use of agricultural environmental subsidies, as long as those subsidies have no or minimal "trade-distorting" and production effects, are part of an clearly defined government program, and cover only added cost or lost income (48). Such payments are not subject to treaty subsidy reduction commitments, and are not subject to countervailing duties or to multilateral subsidy dispute challenges during a nine-year "peace clause." After that, they can be challenged if they are thought to have been abused (e.g., used as disguised production subsidies). Obviously, this provision for agricultural environmental subsidies conflicts with the PPP and previous GATT policy, unless the subsidies are used to enhance environmental quality levels beyond those considered social norms, i.e., provide positive environmental services.

U.S. officials estimate that the URA will subject the nation's environment to a small amount of direct pressure from agricultural production growth that, diffused over an extended period, will lead to environmental losses and gains. They also believe that the URA will indirectly improve environmental quality by encouraging specialization and larger farms that are better able to adopt and employ environmental technologies; through larger consumer incomes and demands for safe food and less pollution; and by leading to less marginal land in production (48). Specific evidence on the nature and magnitude of these effects is not provided.

The NAFTA provisions are generally considered to be substantially "greener" than those of the new GATT accord. But whether all of the NAFTA provisions are entirely workable is not clear. Hufbauer and Schott, for example, observe that complaining NAFTA parties may find it difficult to prove that another member has intentionally lowered environmental barriers to encourage investment. The efficacy of the NAFTA environmental provisions and institutions hinge on the strength of public agency and private interest group commitments to carrying out the skeleton arrangements in the agreements (6). Taken together, however, the new GATT and NAFTA "environmental" provisions constitute a novel attempt to incorporate some environmental concerns into international trade agendas, although they do not, as written, deal in any detail with transboundary or global environmental effects of expanded trade.

Environmental Trade Measures

Clearly, not all trade-related environmental problems will fall under NAFTA and URA provisions. Tropical forest destruction, greenhouse gas buildup, ozone depletion, and species extinction, for example, are among the "global commons" issues that potentially affect or are affected by policies and practices related to trade. For example, Malaysia's cutting of tropical forests has affected the environment beyond its borders, but forest production and trade policy choices understandably remain a national prerogative (31). As noted previously, methyl bromide, which is used extensively in production and to kill HNIS on imports, damages the ozone layer.

Trade measures such as embargoes, sanctions and quarantines, offer possible instruments for addressing environmental problems outside trade pacts. With varying degrees of success, trade measures are used in international environmental agreements, such as the Montreal Protocol on Substances that Deplete the Ozone Layer and the

Convention on International Trade in Endangered Species of Wild Fauna and Flora. Several hundred "legal instruments" are in place to deal with international environmental issues (12). These instruments come in a wide variety of guises, and have differing degrees of potential efficacy and effects on trade (14). For example, Barrett (8) reasons that the Montreal Protocol will sustain itself with the help of the threat of credible and substantial trade restrictions because the potential benefits from collective cooperation in ozone reduction outweigh the compliance costs. As of 1992, only 17 international environmental agreements employed trade measures (30). Esty had counted 20 by 1994, including a few that directly or indirectly relate to U.S. agriculture, such as the International Plant Protection Agreement (which relates to HNIS) and a code of conduct on pesticide distribution and use (23). Understandably, many of these environmental trade measures (ETMs) pertain to resources such as marine fisheries and wildlife, which cross borders, or to global environmental phenomena such as air pollution.

Many types of ETMs exist, including domestic standards, domestic taxes, import/export restrictions, and sanctions. Charnovitz (14) discusses the wide variation in degrees of unilateralism, scope of discrimination, degrees of intrusiveness, and beneficiaries of restrictions, and concludes that ETMs have existed since the 1800s and are not just the invention of "green" activists. Also, based on a review of actual ETMs, clean distinctions between product and process standards, between unilateral versus multilateral actions, and between trade and environment instruments are easier in theory than practice.

Combining many dimensions of ETMs, Esty sorts potential "offensive" uses of trade measures for the environment into four types of approaches:

- "trade restrictions or sanctions expressly authorized by international agreement and imposed multilaterally;
- unilaterally imposed trade measures employed in support of internationally agreed standards (and thus at least tacitly internationally condoned);
- unilaterally imposed trade measures invoked without the benefit of any multilateral agreement but aimed at global or transboundary harms affecting the country imposing the measures;
- unilaterally imposed trade measures invoked without any multilateral agreement and aimed at extraterritorial harms with no direct physical impact on the country imposing the measures (23)."

Category 1 is the option preferred by the WTO and the most common type of agreement. This kind of ETM may have the greatest potential to remedy global environmental problems that extend over large areas. The second category covers "multilateral unilateralism" and can be "legitimate" even in the absence of multilateral action. U.S. trade measures against Norway for violating the International Whaling Commission's rules are an example. Dispute panels have traditionally ruled against a country acting alone—that is, "unilaterally"—and using trade provisions to achieve environmental responses outside a country's borders—that is, "extraterritorially." However, the U.S.-EU tuna-dolphin dispute panel did not find either type of action illegal (48). Although unilateral-extraterritorial measures may be legal under GATT, their efficacy and efficiency in resolving transboundary and global environmental problems requires careful review. If the offending country has access to other markets for its environmentally damaging exports, then unilateral action may be insufficient. Also, the possibilities of transshipment may negate the direct export sanctions. In such cases, other types of actions—such as technical or financial assistance, or institutional reform—may be more effective and have fewer negative repercussions for international trade.

Understandably, the preference for multilateral actions and restrictions over national actions stems from WTO's focus on permitting traded goods to move freely, and on avoiding discrimination against foreign products through nontariff barriers. Not surprisingly, the WTO preferences may not be in line with environmental reality. Many of today's transboundary and global environmental problems may not be remedied through product approaches and multilateral agreements. Increasing attention is being given to the application of process and production method (PPM) measures, because environmental damage stems from those processes, rather than from products. (See appendix II.) However, because it is difficult to monitor and judge their legitimacy, PPMs can potentially be used as disguised nontariff trade barriers for a number of sectors, including agriculture.

When only one country incurs physical environmental injury, unilateral action may be the only recourse. The key issues, according to Esty, are whether a bona fide environmental injury exists, and who applies the standard (23). Such multilateral conflicts highlight GATT's past inattention to environmental matters and the absence of an effective international environmental body to handle such issues. The new WTO Trade and Environment Committee may help clarify some issues. Until an acceptable consensus test for the legitimacy of environmental measures affecting trade emerges, the offensive use of such measures will remain controversial and risky. "The response to international environmental problems remains uncoordinated, unfocused, insufficient, and susceptible to competitively driven disregard" (24). As a result, global commons problems—including those affecting and affected by agricultural production—may be unlikely to improve consistently and significantly overall.

In the end, it appears that existing trade-related institutions do not, and other proposed institutions may not, have the funding, efficacy, or flexibility to deal effectively with transboundary and/or global environmental issues (including agricultural linkages) related to trade. Strikingly, however, there are numerous institutions and agreements whose functions may be complementary, and whose overall focuses and objectives may be similar. In the short run, it may behoove the parties to these institutions and agreements to better coordinate their efforts in the interests of efficacy and economy, particularly given the straitened governmental budgets of the 1990s. In the long run, institutions that address various agendas and efforts may be needed. Suggestions for both short-run and long-term solutions are considered in the last chapter of this report.

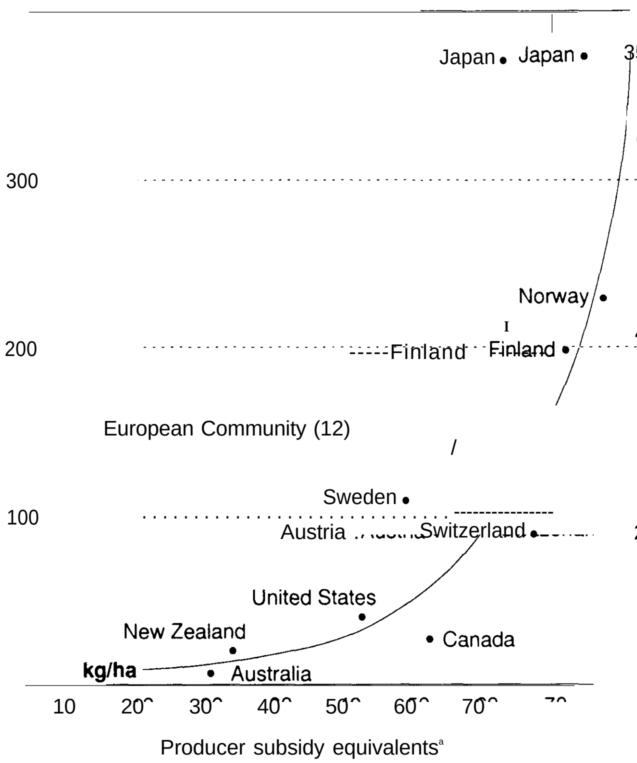
APPENDIX I: POTENTIAL ENVIRONMENTAL EFFECTS OF COMMODITY PROGRAM REFORM AND TRADE LIBERALIZATION

This appendix examines the three types of analyses that have been performed on the potential environmental effects of commodity program reform and international trade liberalization. The first type takes a global perspective; the second considers the U.S. situation; and a third looks at the regional effects of liberalization and program reform within the United States.

Examples of global studies include those by Anderson and by Lutz. In scenarios for world trade liberalization in 1990, Anderson (2) found that world food production changes very little, but shifts away from the highly protected agricultural sectors of the industrialized countries to the agricultural sectors of developing countries—especially when developing countries stop taxing their own farmers. World food prices rise mainly because farmers in countries where subsidies are reduced stop overproducing. The total long-run economic gains, which accrue principally to producers and taxpayers, are about $60 billion to $100 billion. If it is assumed that only developed countries will implement the reforms, and that developing countries still produce less (because they continue to tax their farmers), food prices rise more.

The environmental effects of world trade liberalization have been inferred from the regional nature of changes in agricultural production. Such estimates do not, however, include any detailed analysis of natural resource conditions. It is clear, however, that the global use of agricultural chemicals and intensive livestock feeding decline as crop and livestock production move to developing countries, where farmers tend to use fewer chemicals and more land than in developed countries. Moreover, farmers in developed countries will likely use fewer chemicals as their subsidies

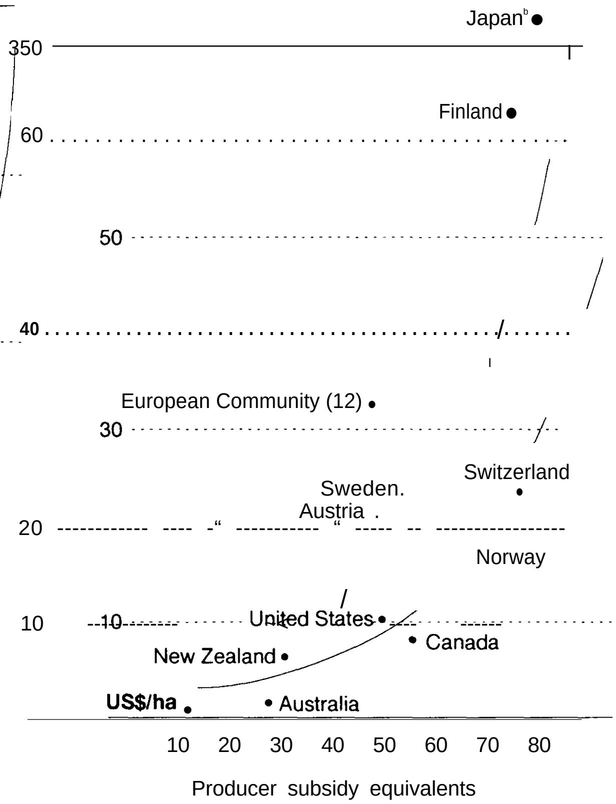
FIGURE 5-1: Average Rate of Fertilizer Use and Producer Assistance in OECD Countries, 1986-89



[a]The producer subsidy equivalent is a measure of the value of monetary transfers from domestic consumers and taxpayers to producers, expressed as percentage share of the total value of farm production

SOURCE: K Parris and J. Melanie, "Japan's Agriculture and Environmental Policies. Time to Change, "*Agricultural and Resources Quarterly* 5(3):386-399,1993.

FIGURE 5-2: Average Rate of Pesticide Use and Producer Assistance in OECD Countries, 1986-89[a]



[a]Expenditures have been converted to U S dollars by the OECD's Purchasing Power Parities

[b]Japan's pesticide use is US$378/ha with a PSE value Of 74 percent

[c]The producer subsidy equivalent is a measure of the value of monetary transfers from domestic consumers and taxpayers to producers, expressed as a percentage share of the total value of farm production

SOURCE: K. Parris and J Melanie, "Japan's Agriculture and Environmental Policies: Time to Change,"*Agricultural and Resources Quarterly* 5(3):386-399, 1993.

decrease. Figure 5-1 displays the general association between fertilizer use and the degree of producer subsidization in OECD countries, a positive and increasing relationship between application rates and subsidy level, known as the producer subsidy equivalent (PSE). A similar relationship exists for pesticides (figure 5-2). The portrayed relationships do not account for variations in soils, climate, or other production factors, but the associations are striking. In Anderson's view, reductions in chemical use and the globalization of livestock production would likely reduce the pressure that agricultural production brings to bear on the environment. Some environmental damage would inevitably occur in developing countries that produce more, but Anderson argues that their increased incomes will eventually provide the means for better environmental control. Fears of widespread deforestation are not well-founded, because the evidence indicates that farmlands in developing countries will not expand much even if prices go up (13). Some reforestation will likely occur in developed countries when programs for land set-asides are discontinued.

In a similar study, Lutz also projects positive environmental outcomes for the industrialized countries. He is less optimistic about stemming environmental damage from increased agricultural production in developing countries, however, and concludes that the net effects of liberalization and reform on the environment are unclear. Lutz acknowledges that removing subsidies for fertilizer and other inputs and introducing effective environmental programs in developing countries, could lead to a positive outcome for the global environment. As explained in the chapter, environmental standards generally rise as a country's income increases.

The Anderson and Lutz studies of necessity have little detail on environmental changes because of their aggregate focus. However, their findings illustrate a fundamental point: agricultural program reform (liberalization) is not likely to reduce the overall scale of world production a great deal, but the regional composition of agricultural production, and technology, will shift significantly, from developed to developing economies, thus raising concern about the efficacy of environmental management in developing countries affecting transboundary and global resources.

Reliable estimates of the environmental impacts engendered by such trade and production shifts continue to elude current science. As an example, Antle and Crissman (4) illustrate the difficulties of forecasting precise environmental outcomes of trade and production shifts among Ecuadorian farmers under simple reforms. Therefore, while some analyses of the effects of aggregate shifts suggest that stress on the global environment may be alleviated, they hinge on the supposition that effective environmental programs are in place.

A second type of study focuses on the overall effects of U.S. commodity policy reform, without considering reform efforts by other countries. Such a scenario is unlikely because the United States alone would suffer production and trade losses if other countries continued to subsidize agriculture, but it offers some insight into possible national adjustments. One group estimated how crop production and resource use would change in the late 1980s, if direct income payments to farmers were substituted for commodity-specific incentives, and if annually diverted land under the Acreage Reduction Program (ARP) were allowed to return to production (46). (Land held out under the Conservation Reserve Program (CRP) would remain fallow.) In other words, given this scenario, incentives for farmers to produce more crops fall, and more land becomes available. Conceptually, production could increase or decrease, depending on the balance between the reduced incentives and the availability of more land for production. Empirically, the authors estimate that overall U.S. farm output would decline—in essence, that the impact of the reduced incentives outweighed the attractions of increased land. Total erosion increased because more land was being tilled, but chemical use declined. Table 5A-1 presents estimates of changes in environmental stress from a base case in which commodity programs continued. Generally, the shifts were small in relation to total figures, varied significantly over regions due to changes in crop mixes and technology, and amounted to substituting more land and erosion for fewer chemicals. The increases in erosion came from more land being planted. The chemical decreases came from shifts in the mix of crops, as well as lower crop prices. The authors point out that the magnitude of short-run effects depends on the strength of commodity program incentives when reform is undertaken. It is worth noting that if all CRP land were allowed to return to production, erosion and chemical use would increase.

Tobey and Reinert (75) also analyzed reductions in U.S. price and income supports as measured by PSE decreases, and in ARP set-aside reductions. The CRP was retained, as in the previous study. Their estimates for combinations of 20 and 40 percent PSE and ARP reductions show environmental damages decline from 3 to 11 percent. Lower fertilizer use is judged to outweigh the effects of increased erosion from reduced ARP set-asides causing higher offsite sedimentation damage. In general, the greater the substitutability between ARP lands and fertilizer, the greater the environmental improvement. In the longer term,

TABLE 5A-1: U.S. Intermediate-Run Resource Effects of Simulated Agricultural Policy Reform in 1990*

	Changes				
	Corn	Cotton	Soybeans	Wheat	4-Crop total
Erosion (10,000 tons)	+ 164	-44	-1,284	4,874	3,709
N (1 ,000 tons)	-420	-15	-4	10	-429
P_2O_5 (1 ,000 tons)	-75	-3	-19	16	-81
Herbicides (10,000 LB)	-1,075	-12	-663	-45	-1,795
Insecticides (10,000 LB)	13	-20	-85	-45	-135

'Conservation Reserve Program retained

SOURCE: J. Miranowski, J. Hrubovcak, and J Sutton, "The Effects of Commodity Programs on Resource Use," *Commodity and Resource Policies in Agricultural Systems,* R Just and N. Bockstael (eds.) (New York, NY Springer-Verlag,1 991).

which neither the Miranowski, et al., nor the Tobey and Reinert studies could fully explore, greater substitution is likely as operators exhaust all management techniques, and as new technologies emerge to use the less expensive land and conserve relatively more expensive inputs such as pesticides and fertilizers. The increased erosion and runoff clearly indicate that management programs are a key factor in determining the eventual environmental outcome of any commodity policy reform.

The third type of analysis examines the consequences of policy reform for specific U.S. regions. A study performed by the World Resources Institute looked at what might happen if there were a multilateral move to reform commodity payments into income supports, and if export subsidies and import restrictions were simultaneously eliminated by major trading countries (25). Global food supplies were estimated to decrease and world food prices to rise. Economic and environmental effects were estimated for case farms in Pennsylvania and Nebraska, compared to 1985 base levels. A special feature of the analysis was its incorporation of "natural resource accounting" methods, under which the environmental costs of farming, such as soil degradation and offsite water pollution, were charged against crop profits-an illustration of the polluter-pays principle (PPP) detailed in the chapter 5 text. Table 5A-2 displays the estimated effect on net farm income for various crop rotations on the Nebraska farm, without and with natural resource accounting and a soil depreciation charge.[11] The estimates suggest that if trade is liberalized and the PPP applies, farmers would make as much money by growing some rotations that put less stress on the environment. Increased profits would stem primarily from a combination of higher prices and lower production costs.

Another regional study estimated that increases in target prices and other supports make the adoption of irrigation technology more profitable and thereby increase groundwater depletion in Nebraska's northern Ogallala aquifer (35). The combination of price supports and set-asides was estimated to substantially increase depletion within five years of implementation. Table 5A-3 shows the estimated effects. A third regional study estimated that a 50-percent reduction in commodity program price support would decrease irrigated water use by one-third in the Plains and Pacific states (33). In essence, the reduced program incentives make it less profitable to grow program crops that need large amounts of water. The figure was smaller for the Mountain states, where

[11] The rationale for deducting soil depreciation charges through an external environmental policy is unclear. Several studies have shown that soil depreciation through erosion and other processes are reflected to a considerable degree in expected net returns and cropland prices (45). If such internal accounting is accurate, external charges are redundant.

TABLE 5A–2: Estimated Change in Net Economic Value[a] Under Agricultural Program Reform (Nebraska Case Farm) Net Economic Value and Change in Net Economic Value ($/acre/4 years)

	CC	HFCB	FOCB	ORGCB	HFROT	FOROT	ORGROT
Baseline NEV	72	480	483	474	348	344	340
MLDC NEV	250	561	561	553	458	449	445
Increase	(233)	[b] 78	78	70	(25)	(34)	(38)
	(483-250)	(561-483)	(561 -483)	(553-483)	(458-483)	(449-483)	(445-483)

NEV - Net economic value
c c - Conventional continuous corn
HFCB - Conventional corn-beans, w/herbicides and fertilizer
FOCB - Corn-beans w/fertilizer but no herbicides
ORGCB - Organic corn-beans
HFROT - Corn- beans-corn-oats/clover w/herbicides and fertilizer
FOROT - Corn- beans-corn-oats/clover w/fertilizer but no herbicides
ORGROT - Organic corn-beans-corn-oats/clover
MLDC - Multilateral Decoupling

[a]Increases (or decreases) in Net Economic Value for each rotation are based on the most profitable conventional rotation--the fertilizer-only corn-beans rotation (FOCB)--under baseline policy The table shows the result of a movement from FOCB under baseline policy to the given rotation under multilateral decoupling
(MLDC $NEV_{ROTATION}$ - Baseline NEV_{FOCB} = $Increase_{ROTATION}$)
These calculations assume output prices as in table 4 of Faeth et al. (1991 for Multilateral Decoupling)
[b]Figures in parenthesis are negative.

SOURCE: P. Faeth et al., "Paying the Farm Bill: U.S. Agricultural Policy and the Transition to Sustainable Agriculture" (Washington, DC World Resources Institute, March 1991), p 15

TABLE 5A–3: Results of Simulations of Agricultural Program Effects on Irrigation Water Use

	Effective price of wheat (dollars per bushel)			Effective price of corn (dollars per bushel)			Irrigated acreage		Average pumping lift (feet)	
Scenario	1984	1985	2004	1984	1985	2004	1985	2004	1985	2004
Base	3.8354	37949	37700	3.1600	2.8719	2,8527	710,066	701,561	123.59	125.82
1	3,8341	3.7932	37569	3.0737	2,8714	2,8527	711,209	711,208	126,25	125,75
2	3.8366	4.0125	48647	3.2495	3.0950	4,0869	723,757	796,816	126,85	130,27
3	3.5961	3.4882	3.4168	3.0542	2.5992	2.0187	690,377	632,134	125,23	122,28
4	4,1304	4.1022	5,6325	3.2652	3.1449	4.5065	730,475	818,173	127,17	131,20
5	4.0164	39877	4.7115	3.1323	3.0290	3.6735	722,443	757,055	126,79	128,46
6	4,0964	*40431*	*4.0313*	*3.1600*	*2.9946*	*3.6475*	*712,554*	*772,019*	*126,31*	*129,16*

*Scenarios are defined as: 1. A 10% reduction in price supports for wheat and corn (with corresponding changes in price controls for the farmer-owned reserve). 2. A 10% increase in price supports for wheat and corn. 3. A 10% reduction in both price supports and target prices for wheat and corn. 4. A 10% increase in both price supports and target prices for wheat and corn. 5. A 10% reduction in the diversion requirement. 6. Maintain - ing the high diversion and support of 1983

SOURCE: R. Just, E Lichtenberg, and D Zilberman, "Effects of Feed Grain and Wheat Programs on Irrigation and Groundwater Depletion in Nebraska, " *Commodityand Resource Policies in Agricultural Systems,* R E Just and N Bockstael (eds.) (New York, NY Springer-Verlag, 1991), pp. 215-232 profitable alternative crops that also need large amounts of water can be grown.

APPENDIX II: PROCESSES AND PRODUCTION METHODS

An increasingly frequent proposal is to impose trade measures for environmental purposes based on the nature of production processes (termed processes and production methods, or PPMs) (23,93). Process standards may resemble product standards, but the issues and problems are quite different. Product standards deal with the effects of using a product by domestic parties; PPMs are meant to control negative environmental byproducts of the production process in foreign countries. For product standards, the problem is observable and easily monitored, and the actions can be legally exercised under WTO rules by the importing country. For PPMs, the production process occurs outside country borders, is not easily monitored, and cannot be legally used to screen imports under WTO rules. But the rising emphasis on PPMs is critical, because environmental problems generally arise from the production process, not the product.

Sovereignty is an issue central to the notion of PPMs. Can one country demand that the goods it imports from another be produced in what it deems an "environmentally correct" manner? This question has achieved notoriety in the 1990s with the tuna-dolphin dispute first between the United States and Mexico, then between the United States and the EU (48). The dispute began when the United States boycotted tuna imports from Mexico on the grounds that Mexican fishing practices violated the U.S. Marine Mammal Protection Act (MMPA), which restricts certain seafood imports from nations whose fishing practices kill marine mammals such as whales and dolphins. Claiming that such an action violated international trade rules, the Mexican government registered a complaint with GATT.

An initial GATT dispute panel ruling in 1992 found that the U.S. action indeed violated GATT disciplines. GATT, the panel maintained, prohibits a member from taking trade measures to enforce its own laws regarding animals or exhaustible natural resources outside its jurisdiction, and from taking such measures because a foreign country's production methods do not satisfy domestic regulations. At the behest of Mexico, the report ultimately was not presented to or adopted by the GATT Council, which would have had the power to impose actual sanctions. The EU launched a similar case against the United States. In May 1994, a second GATT dispute panel ruled that article XX exceptions could be applied to protect resources outside a country's jurisdiction, but that the embargo was still illegal under GATT, because the action would not effectively achieve U.S. conservation objectives (48). The Office of the U.S. Trade Representative requested a public review of the second GATT decision.

Current WTO rules do not generally permit the use of PPMs to address environmental problems, although the issue was not definitively addressed by the URA. Article III requires that imported goods receive treatment no less favorable with respect to internal laws and regulations than the treatment accorded "like" products of national origin (48). A central issue with respect to PPMs is whether those laws can differentiate between different goods based on the processes or methods used in their production, if those processes or methods are not reflected in the observable and measurable physical characteristics of the product itself .

WTO article III rules potentially conflict with international environmental agreements incorporating trade measures based on PPMs. For example, the Montreal Protocol has established a schedule for the phase-out of ozone-depleting substances by restricting trade in the substances—and restricting trade in products produced with the substances. Because production processes and not products cause much environmental damage, the conflict between WTO's emphasis on avoiding trade barriers and efforts to pursue legitimate environmental objectives is genuine.

What constitutes legitimate environmental activities is another unanswered question. Can a country act unilaterally to restrict the entry of a product made by using inputs that cause environmental damage to the acting country? For example, could the United States restrict the entry of certain agricultural commodities produced in Mexico that use a banned U.S. pesticide which, eventually, migrates into U.S. territory and threatens endangered species? Under current WTO rules, the answer appears to be no. When can several countries act multilaterally to diminish transboundary or global environmental problems and avoid WTO sanctions? These questions capture the extraterritoriality and unilateral/multilateral dimensions of trade-environmental conflicts that are unsettled by WTO or any other organization. As mentioned in the chapter, problems in identifying goods because of transshipment and the advisability of using instruments other than trade measures require consideration in these cases.

A growing number of potential PPM cases, some agricultural in content, are necessitating further discussion and review by international bodies. The OECD has issued a note outlining the conditions under which PPM-based trade measures might be used; their effectiveness, feasibility, and efficiency considerations; and alternatives to such measures (53). Young has also proposed a set of disciplines to guide the use of PPMs that preserve maximum benefits from freer trade while allowing countries to pursue environmental objectives beyond their borders. As noted above, the major PPM issues turn on the feasibility of monitoring processes and production methods in foreign countries—and the potential for abusing them, by using them as nontariff barriers to trade. Using effective low-cost alternatives (e.g., sharing technical assistance and technology) may help to avoid the problems that may accompany PPMs. Consensus positions or principles on PPM use have not been issued. However, as mentioned above, several agricultural cases of product-related PPMs may emerge in the near future, including genetically engineered plants and organic farm products that require clarification of international rules. This topic will likely be one of the key issues for the WTO's new Trade and Environment Committee.

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International Comparison of Agriculture, Trade, and Environmental Policies 6

As expanding trade puts new emphasis on the relationship between agriculture and the environment, it is prudent to examine what effects various policy responses to this relationship will have on national or regional economies, and on U.S. competitiveness in world markets. Are other countries experiencing agroenvironmental problems similar to those of the United States, and how do their responses compare with ours? If the United States regulates agriculture to preserve its environment, will it still be competitive in world agricultural markets? Do other countries offer more support to their agricultural sectors than the United States does? Do other countries restrict agricultural trade more, or less?

This chapter begins to put into perspective the relative position of the United States among its many trading partners with respect to domestic agricultural support policies and agroenvironmental policies. The partners considered here are Argentina, Australia, Brazil, Canada, France, Germany, Japan, Mexico, the Netherlands, New Zealand, Taiwan, and the United Kingdom—a group that includes most of the United States' major agricultural markets and sources of agricultural imports. With some exceptions, these countries share certain economic characteristics: generally, 10 percent or less of their populations are working in the agricultural sector, which accounts for between 2 and 5 percent of total gross domestic product (GDP). As a percentage of total exports, their agricultural exports span a broader range, from 0.4 percent for Japan to 58 percent for Argentina. The United States' agricultural exports make up 11 percent of its total exports. (See table 6-1 for general population and economic information.)

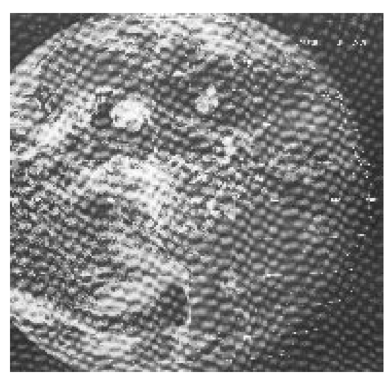

TABLE 6-1: Population and Economic Information

Country	Population (in 1,000s) 1992	Percent of population in agricultural economy	Total land (in 1,000s of Ha) 1992	Percent of land in agriculture 1992	Agricultural GDP as a percent of total GDP 1989	Agricultural exports as a percent of total exports 1991	Agricultural imports as a percent of total imports 1991
Argentina	33,100	10	273,669	10	10	58	4
Australia	17,611	5	764,444	6	5	24	4
Brazil	154,163	23	845,651	7	11	25	12
Canada	27,426	3	922,097	5	3	8	6
France	57,266	5	55,010	35	5	14	9
Germany[a]	80,343	4	34,931	34	FR 6	3	12
					NL 2	5	11
Netherlands	15,179	3	3,392	27	5	23	13
U.K.	57,963	2	24,160	27	2	7	11
Japan	124,150	6	37,652	12	3	0,4'	NA
Mexico	92,342	29	190,869	13	8	10	12
New Zealand	3,417	9	26,799	2	13	52	7
Taiwan	20,400	12	3,601	24	4	NA	NA
U.S.	254,910	2	916,660	20	3	11	5

[a]FR=Federal Republic, NL=New Lander

*1992

NA=Not Applicable

SOURCE: American Institute in Taiwan, Annual Report, *Agricultural Situation,* AGR Number TW3062, 1993; Food and Agriculture Organization of the United Nations, *Country Tables* (Rome, Italy: 1993); Food and Agriculture Organization, *Production Yearbook,* 1992, vol 46 (Rome, Italy: 1993), Food and Agriculture Organization, *Yearbook, Trade,* vol. 46 (Rome, Italy: 1992); U S Department of Agriculture, Economic Research Service, *International Agriculture and Trade Reports: Asia and Pacific Rim Situation and Outlook Series,* RS-93-6 (Washington, DC: September 1993)

Since 1970, agricultural production in OECD[1] countries has expanded by about 40 percent, even though arable and permanent cropland increased by only 3 percent and the agricultural labor force decreased by more than 30 percent. Such a jump in production largely reflects greater use of energy, fertilizers, pesticides, machinery, irrigation, and high-yielding crop varieties. Use of energy and tractors increased by 40 percent in OECD countries over the past three decades; use of nitrogen fertilizers, by almost 60 percent; and areas of irrigated land, by 20 percent (51). It is crucial to note that the increase in production would not have been possible without the support of government policies that, for the most part, did not take into account the environmental impacts of intensive agricultural practices. Now, however, governments are faced with increasing conflicts between long-standing agricultural policies and newly established environmental goals.

All of the countries considered in this chapter intervene in their agricultural sectors to achieve certain national objectives, such as maintaining a secure, safe, and adequate food supply; increasing agricultural productivity; and enhancing living standards of farm families. In recent years, however, budget constraints, international pressure, and socio-economic changes have led most countries to cut back on government support for their agricultural sectors. New Zealand went so far as to eliminate government support altogether in 1984, other than for pest and disease control and some research. Mexico and the European Union (EU) (until 1994, known as the European Community, or EC), have advanced efforts to separate, or "decouple," agricultural support from product prices. As part of its economic reforms, Argentina has drastically reduced the implicit tax it levies on its agricultural sector. Australia and Taiwan are the only countries among those considered that have not decreased their overall support to the agricultural sector in recent years, although Australia appears to be moving in that direction.

All countries use some combination of border measures—tariffs, quotas, export promotions, health and safety regulations, licensing schemes, and other devices—to protect domestic agricultural producers and enhance their opportunities to increase agricultural exports. Taken together, these measures can restrict overall world trade. However, through increased participation in regional trade blocs, such as the North American Free Trade Agreement (NAFTA), and in the World Trade Organization (WTO) (which was until January 1995 known as the General Agreement on Tariffs and Trade, or GATT), many countries are opening their borders to freer trade.

As noted earlier, this move toward freer trade, which has taken place over the past few decades, has coincided with (and in some cases has contributed to) growing environmental concerns and a range of government efforts to address those concerns. By the mid to late 1980s, most governments had instituted at least some environmental legislation and regulations, and had taken moderate measures to help mitigate problems. The implementation, enforcement, and effectiveness of these policies and regulations varies widely from country to country.[2] Among the industrialized countries, there is not a significant discrepancy in the percentage of GDP that is used for pollution abatement and control by the public and private sectors (see also chapter 5). The percentage of GDP spent by the public and private sectors com-

[1] OECD (Organization for Economic Cooperation and Development) member countries are Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Japan, Luxembourg, the Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, Switzerland, Turkey, the United Kingdom, and the United States.

[2] When attempting to compare countries' agroenvironmental policies, it is important to note (1) that a country's state of environmental health must be known in order to determine whether action is even warranted, and (2) that the degree of implementation and enforcement is key to determining the efficacy of policies. This chapter looks only at trends in agroenvironmental policies, and does not systematically address points (1) or (2).

bined for pollution abatement and control ranges from 1.1 percent in France and Japan[3] to 1.6 percent in West Germany and the United States. Expenditures by the public sector alone range from 0.4 percent in the United Kingdom to 1.0 percent in Japan (table 6-2) (53).

TABLE 6-2: Pollution Control and Abatement Expenditures as a Percentage of GDP (1990)[a]

Country	Public sector	Public and private sectors
Canada	0.9	NA
u s	0 6	1.6
Japan[b]	1,0	11
France	0.5	11
W. Germany	0.8	1.6
Netherlands[c]	0.9	1,5
United Kingdom	0,4	1 5

[a]Data on the costs of pollution control in the primary agricultural sector are generally not included in calculations of pollution control and abatement expenditures because the data in this area are scarce

[b]Partial Figure Data of current expenditure for the business sector are not available

[c]Figures for 1989.

NOTE: Table 6-2 shows pollution and abatement control expenditures of both the public and private sectors for air and water pollution. These figures can give an idea of the economic costs a country chooses to face in mitigating pollution However, as a comparison these numbers cannot tell the reader anything about the current state of a country's environment, about the environmental state a country desires to achieve, or the amount of pollution control each country obtains per unit of currency For example, country A and country B could be spending the same percent of GDP on pollution abatement and control, but country A's environment might be twice as polluted as country B's

SOURCE: OECD, Environment Monographs, No 75, *Pollution Abatement and Control Expenditures in OECD Countries* (Pans, France 1993).

Although the nature and extent of the problems may vary, most countries are contending with similar agroenvironmental ills. Until recently, however, the agricultural sectors of most countries were largely excluded from environmental policies and regulations. Often, initial policies addressing agroenvironmental issues focused on soil erosion, because it directly affects agricultural productivity. As agroenvironmental priorities have broadened, however, many countries have begun to include provisions for enhancing water quality, as well as protecting habitats, wetlands, and other countryside amenities in their agricultural policies. Canada, Japan, and the United States have each eliminated their wetlands by more than 70 percent in some regions, but have now introduced policies geared to protecting remaining wetlands that are deemed significant, or to preventing a net loss of wetlands.

Most countries are grappling with the environmental effects of agricultural production by discouraging harmful practices or encouraging beneficial ones. It must be kept in mind, however, that agricultural assistance is still predominantly linked to production rather than to general environmental goals. To a large extent, existing agricultural policies either effectively raise farmers' prices for output or decrease prices for inputs—both of which encourage farmers to adopt intensive farming practices that may be harmful to the environment. Agroenvironmental policies may then be introduced to counteract these effects. However, the artificially high prices for agricultural goods make it difficult for other land uses, such as wildlife habitat, to compete with agricultural uses.

This dilemma is being addressed now by governments the world over. Faced with shrinking budgets, they are finding it more and more difficult to rationalize maintaining such conflicting policies—and they are increasingly unwilling to pay not only the' financial, but also the environmental, costs of supporting their agricultural sectors as they did in the past. Partly as a result, agroenvironmental policies are moving away from strictly voluntary efforts to cross-compliance schemes and mandatory measures. These policies may cause production costs to rise, but if all, or most, countries are implementing similar policies and all face increased costs, the ultimate effects on competitiveness may be minimal. U.S. farmers may face less severe tradeoffs between productivity and environmental protection than some of their European counterparts, because they

[3]This is a partial figure, as data on business sector current expenditure in Japan are not available.

use inputs less intensely and their arable land area is more extensive (62).

In the context of this chapter, it is not OTA's intention to determine which countries have cleaner environments, which countries have more stringent regulations protecting the environment, which countries have been more successful in implementing agroenvironmental laws, which countries have the freest trade policies, or which countries offer the most support to their agricultural sectors. Instead, the chapter focuses on the trends mentioned previously: movements toward less government support of the agricultural sector, more open borders, and more stringent, or at least explicit, agroenvironmental policies. The first section of the chapter briefly examines the agriculture and agricultural trade policies of each country. It demonstrates the many similarities among countries in their agricultural sector goals, in the problems they face, and in the evolution of events over the past few decades. The second section focuses on some of the environmental concerns increasingly being incorporated into agricultural policies and regulations. Examples again show remarkable similarities among countries in the kinds of agroenvironmental problems they face, and in their responses to those problems.

TRENDS IN AGRICULTURAL SUPPORT AND TRADE POLICIES

As noted above, all governments intervene in their agricultural sectors to achieve certain national objectives related to food supply and farm income. To achieve these objectives, governments employ combinations of price supports, subsidies, and market boards, as well as trade measures such as tariffs, quotas, export promotions, and licensing schemes. Health and safety regulations, although designed to protect consumers and the environment, can also be used to restrict trade. To varying degrees, these policies affect how domestic goods are produced, have negative effects on world market prices, and restrict international trade flows.

Such economically undesirable results, along with tighter budget constraints, have led governments to offer less support to their agricultural sectors than they previously did. Further fueling the move toward less support is the increasing importance of international trade agreements, which have put pressure on countries not only to reduce their trade barriers, but to cut back on domestic subsidies. Even though the Uruguay Round of the GATT put the agricultural sector squarely on the negotiating table, it is not clear to what extent government policies will actually change. However, most countries have already taken measures to reduce government support of their agricultural sectors.

In this regard, New Zealand is a unique example: it essentially eliminated government support for agriculture in 1984, and its government transfers to farmers are now the lowest in the industrialized world (69). Mexico has also taken significant steps to reduce government support by introducing, in 1993, an agricultural reform program called PROCAMPO, which decouples farm income support from production decisions and moves its agricultural sector significantly toward a market-directed system. The EU, too, has made efforts to decouple agricultural support from yield, although not to the extent of New Zealand and Mexico.

The extent of government transfer payments to agricultural sectors is commonly measured by using producer subsidy equivalents (PSEs). The Economic Research Service (ERS) of the U.S. Department of Agriculture (USDA) began calculating PSEs in 1986, for use in the Uruguay Round of the GATT negotiations. PSEs are intended to provide an overall measure of government policies that support agriculture, and so offer a means of comparing programs from country to country and over time. What they show, in effect, is the amount of compensation that would be required to maintain farmers' incomes in certain agricultural sectors, if government polices affecting agriculture (both agricultural and trade policies) did not exist. This report uses an aggregate PSE for all agricultural sectors, which demonstrates the extent of subsidies or implicit taxes relative to farmers' gross revenues (73).[4]

An analysis of the percentage change in PSEs between 1985 and 1992 clearly demonstrates a trend toward less intervention by governments in the agricultural sector, including the elimination of many government-supported marketing boards (table 6-3). New Zealand's and Mexico's PSEs changed the most, decreasing by 91 and 73 percent, respectively.[5] The PSEs for the United States, the EU, and Canada decreased by 35, 33, and 9 percent, respectively. The increased PSE for the United States during 1991 and 1992 reflects, in part, an increase in direct payments as export subsidies for rice. Japan's PSE decreased by only 10 percent, and the PSEs for Australia and Taiwan increased. The change in PSEs for Argentina, dramatic at 66 percent, is unique because it does not reflect declining government subsidies for agriculture. Instead, Argentina has reduced the implicit tax on the agricultural sector in a move toward a more market-driven agricultural economy. The PSE for Brazil has varied widely, making it difficult to ascertain a clear trend. The policies and economic forces behind these trends are discussed in more detail in the country sections below.

New Zealand

In 1984, New Zealand initiated major reforms in the structure of its economy, including agriculture (the leading economic sector) and the highly protected manufacturing sector. An increase in the public debt, from 10 percent of GDP in the early 1970s to more than 50 percent of GDP in the early 1980s, was the impetus for the reforms. Part of the reason for the debt was New Zealand's loss of favored-nation trading status with the United Kingdom when the UK entered the Common Market. The United Kingdom had accounted for two-thirds of New Zealand's export market. But high oil prices, unfavorable conditions in the world commodity markets, and the protectionist policies of New Zealand's main trading partners also made the country's support for its agricultural and manufacturing sectors unsustainable.

Before the mid-1950s, New Zealand's agricultural sector had needed little government support. During the late 1950s and 1960s, however, commodity prices fell, and the government severely restricted imports, in order to stimulate expansion in its manufacturing sector. By the mid-1960s, the government had also introduced policies to maintain or increase agricultural production whenever farm incomes declined. From the mid-1970s, and particularly from 1980 to 1984, government intervention in the agricultural sector became extensive (57), even though its support could not offset excess costs indirectly imposed on agriculture from government protection of the manufacturing sector. Government protection of the manufacturing sector artificially increased farm input and labor costs. Such support also proved extremely expensive. By 1983, government assistance for the livestock sector, the country's primary agricultural sector, was more than 33 percent of the sector's total value (35). Support also stunted diversification efforts because it favored some products, such as sheepmeat, over others (57). More than half of government support to agriculture between 1980 and 1984 consisted of price supports and direct payments to boost output.

[4] USDA/ERS notes four caveats pertaining to PSEs. First, variations exist in how policies are included in determining each commodity PSE and which commodities are included in determining the aggregate PSE. Variations here could significantly change the nature of the data. Second, some developing countries do not include the effects of exchange rate policies, which can be an important component in the PSE measure. Third, the reliability of the data varies from country to country. Fourth, a country can lower the percentage PSE without changing total transfers to producers merely by shifting transfers from indirect programs to price support programs or direct payments (73). This report uses the numbers to determine trends of government support within a country rather than among countries.

[5] Percent changes in PSEs, except for New Zealand and Argentina, are calculated by using the 1986, 1987, and 1988 average as a base year. This base was chosen because it was used during the GATT negotiations. For New Zealand and Argentina, 1985 was used as the base year to show the changes that resulted from their reform efforts prior to 1986.

TABLE 6-3: USDA Percent Producer Subsidy Equivalents for Various Countries

Country	Item	1985	1986	1987	1988	1989	1990	1991	1992	Percent change using 1986–1988 average as base year[a]
Argentina	4-commodity	-31.5b	-24.4	3.0	-175	-46,6	-65.6	-28.3	-10,8	+66[c]
Australia	9-commodity	9.4	10.9	7.5	6.7	6.4	9.9	NA	NA	+18
Brazil	6-commodity	26,9	30.8	-8.1	NA	NA	NA	NA	NA	NA
Canada	13-commodity	36.0	41,5	41,0	33.5	34,4	36.7	39,1	36.0	-9
European Union	13-commodity	357	477	51.4	38.1	30.1	NA	NA	NA	-33
Japan	10-commodity	70,0	76.9	78,7	77.4	71,0	70.8	NA	NA	-lo
Mexico	14-commodity	26.1	34.0	36.5	20.9	14,9	17,1	12,3	8.0	-73
New Zealand	5-commodity	22.0	9.0	5.0	3.0	2.0	NA	NA	NA	-91[d]
Taiwan	11 -commodity	24.6	24.7	24,7	25,9	29,2	28.6	28.3	31.6	+26[e]
U.S.	12-commodity	23.4	34.2	31.5	23.5	18,5	18.0	18.8	19.3	-35

[a]The end year used to calculate percent changes varies among countries and is the latest year for which there are data.

[b]A negative number represents an implicit tax on the agricultural sector.

[c]The change in PSE for Argentina between 1985 and 1992 indicates that the implicit tax on agriculture has decreased by 66 percent

[d]Using only 1985 as the base Year

[e]The aggregate PSE for Taiwan increased even though there were no major policy changes that occurred during this period The increase is due in part to high guaranteed purchase prices for all the crops included in the 11-commodity aggregate.

NA = Not Available.

SOURCE: U.S. Department of Agriculture, Economic Research Service, *Estimates of Producer and Consumer Subsidy Equivalents,* Statistical Bulletin 913 (Washington, DC December 1994).

The principal goals of deregulation and liberalization were to lower inflation and interest rates throughout the economy and to secure more favorable exchange rates. The agricultural sector initially supported these changes, and reform was essentially completed by 1988. Supplementary minimum price schemes were eliminated, along with low-cost funds provided to producer boards. The PSE for New Zealand decreased from 32 percent in 1982 to 2 percent in 1989. Most of the current support is in the form of research and training, pest and disease control, and natural disaster assistance. Although the effective rate of assistance to both agriculture and manufacturing has declined, assistance to agriculture has decreased more rapidly, resulting in an implicit 6-percent tax on agriculture. In 1991, the government introduced additional measures to reduce this implicit tax (35,57).

These reforms have had a powerful impact on New Zealand's agricultural sector. The severity of initial conditions, rapid implementation of the reform policies, imbalances in structural reforms among sectors, uncertain economics of world agricultural markets, and severe droughts in 1988 and 1989 have all contributed to a long and difficult adjustment period. However, the advantages of the reform measures are now evident. Overall, since policy reform, public debt has risen less rapidly than GDP, and fiscal surpluses are expected for 1994-1995 and subsequent years. The double-digit inflation rates of the 1970s and 1980s have dwindled to about 1 percent since 1990. Generally, reform has contributed to a more diversified and resilient agricultural sector. Specifically, reform has affected land use and values, the nature and quantity of input use, employment, investment, and trade.

Although data on farm size and land use are incomplete and do not allow for detailed analysis on land use changes, some trends can be discerned. On the whole, the number of large and small farms has increased (42,44). The percentage of farms whose debt exceeds 50 percent increased from 10 to 24 percent between 1984 and 1986, but by 1992, the percentage of these highly indebted farms decreased to 9 percent, as they either restructured their debt or were sold. At the other end of the scale, the percentage of farms with low debt increased from 14 to 21 percent between 1986 and 1992. These farms managed to increase their savings continuously throughout these years, with the exceptions of 1986 and 1989. The total area farmed decreased from 21.2 to 17.3 million hectares between 1984 and 1993. Conversely, though, the number of farms increased during the same period, from 76,633 to 79,666, and permanent full-time employees increased from 22,787 to 23,310 between 1984 and 1991 (35). Between 1982 and 1988, real farmland values fell by more than 50 percent, demonstrating the extent to which government support for agriculture was capitalized into the value of farmland. But by 1993, real land prices had risen to about 88 percent of their 1982 levels.[6]

Subsidies in place before reform heavily favored sheep production. Now, in the absence of subsidies, sheep production has declined, and beef and dairy production have increased (67). The number of sheep, for example, decreased from 70 million in 1982 to 52 million in 1992.[7] Without government subsidies, many sheep farms operating in marginal environments, such as high-country pastures, were no longer viable. Many of these areas were planted with private forests (35). The amount of land in forestry increased 39 percent between 1983 and 1993, while sheep, beef, and cropping land has decreased 10 percent (5). With the elimination of accelerated write-offs for machinery and development costs, as well as the elimination of import restrictions on cereal crops, arable farming has also declined. The fruit and vegetable sector, in contrast, has increased in area and value.

[6] Information supplied by the New Zealand Ministry of Agriculture and Fisheries, Agriculture Policy, External Relations, 1994.

[7] Information supplied by the New Zealand Ministry of Agriculture and Fisheries, Agriculture Policy, External Relations, 1994.

New Zealand's natural disaster assistance policy has also undergone extensive changes, to make it more consistent with overall economic objectives. The goal is to ensure that adverse-events assistance policy does not impede agricultural restructuring. Under a risk-sharing policy, for example, one area of New Zealand received assistance for drought every year from 1978 to 1986. The government has been working to tighten the criteria for eligibility. In 1986, specific meteorological criteria, such as soil moisture deficits, were developed to determine whether an event would be classified as "adverse" (43).

Agriculture contributed about 20 percent to New Zealand's GDP in the 1950s, but only 13 percent between 1990 and 1992. Overall, total agricultural exports have increased in real terms by 1 percent (183 percent in nominal terms) between 1984 and 1992. Exports of pastoral farm products (e.g., products from sheep) decreased, but exports of meat, dairy products, and fruit and vegetables increased. Although agricultural exports still dominate, they fell as a percentage of total exports from an average of 67 percent between 1979 and 1981 to 54 percent in 1991 (19).

Mexico

Mexico joined GATT in 1987, and since then has privatized much of its economy, including activities related to agriculture. Mexico's most recent and comprehensive agricultural reform policy, PROCAMPO (Programa de Apoyos Directos al Campo), was first announced in 1993. It is designed to move the country's agricultural sector closer to a market-driven system and to work in concert with NAFTA to liberalize trade. Average tariffs on imports have since dropped from 45 to 9 percent.

PROCAMPO replaces price supports, which were often well above international levels, with direct income supports. Input subsidies, except for electricity, have been abolished, and import licenses, tariffs, and state trading companies no longer offer the agricultural sector any significant protection (4). PROCAMPO should help diminish incentives for overproducing the commodities included in the program: corn, beans, wheat, rice, cotton, soybeans, safflower, barley, and sorghum. These are the crops planted by 85 percent of Mexico's agricultural producers. The program was initiated from 1993 to 1994, and should be fully implemented by 1995. For the first 10 years of the program, producers will receive fixed payments (in real terms), which will be phased out over the following five years. The Mexican government estimates that the program will initially increase its outlays in 1995, but reduce them in subsequent years (71). As part of its NAFTA commitment to liberalize trade with the United States, the government of Mexico has begun to upgrade its health and safety regulations, although the regulatory authorities have few resources with which to pursue their tasks (4).

The recent reform of Mexico's land tenure system has contributed significantly to the drastic changes taking place in Mexico's agricultural sector, because it allows increased participation by the private sector. Until 1991, article 27 of the Mexican Constitution of 1917 required the government to give land to any group of farmers who claimed property rights in accordance with the applicable legislation, even if it meant expropriating unused and underused land from private owners. Individuals could not own the land, but they could form communal groups called *ejidos*, and work the land collectively. Between 1917 and 1987, approximately 100 million hectares had been expropriated and more than 50 percent of Mexican farmland was operated under the *ejido* system. However, in an attempt to prevent the reappearance of large land holdings, *ejidos* could not sell, rent, or use the land for collateral before 1991.

Mexico's agricultural trade balance dropped from a surplus of 2.3 percent of GDP in 1960 to a 0.3 percent deficit by 1980. Despite its very favorable conditions for agriculture, Mexico has become a net importer of food (including maize and wheat). Partly in response, a 1991 amendment to the country's constitution paved the way for corporate investment, joint ventures, and private ownership of *ejidos*, to encourage modernization. These changes are intended to provide more security to agricultural land investors, protect against expropriation, allow *ejidos* to rent their land, and create a foundation for greater capitalization of the agricultural sector. New investors seem particularly interested in the prospect of growing fruit and vegetables. Although the new legislation does not change the allowable size of individual land holdings (100 hectares of irrigated land for row crops per individual, 300 hectares for orchards, or enough land for 500 head of cattle), it allows the creation of associations or corporations that can own up to 25 times the amount that individuals can own (2,500 hectares of irrigated land for row crops, 7,500 hectares for orchards) (10).

These reforms are creating significant adjustment problems. In the long term, as many as 90 percent of Mexico's 2.4 million maize producers could be dislocated, and overall, a total of 3.5 million small and medium-size farms (10,85). Dislocation in the short term could be limited not only because investors might find it difficult to acquire fragmented land, but also because they might move cautiously at first, waiting to see how the new law plays out in the courts. There has also been a sharp decline in the agricultural share of GDP as the nation's economy has expanded: agriculture as a percentage of total GDP was 8 percent in 1989, but dropped to 5.8 percent by 1993 (4,19). In addition, input prices have risen as commodity prices have fallen, affecting the use of fertilizers, pesticides, and improved seeds. According to the American Embassy in Mexico City, farm organizations have orchestrated large demonstrations to demand some transitional help, such as the restructuring of outstanding loans (4). Estimates of farm loans in default range as high as $4 billion. The government decided that its bank, which holds approximately 33 percent of delinquent loans, would stop seizing assets in response to loan defaults (61).

USDA estimates that the policies of PROCAMPO will lead to lower producer and consumer prices for all crops in the program. Lower producer prices should lead to fewer acres planted with corn—an estimated 700,000 hectares in the first three years. At present, Mexico's primary crop is corn, which accounts for more than half of Mexico's cropland and more than 40 percent of the country's total crop value. About 34 percent of corn output is consumed on the farm, which means that many farmers have not benefited from price supports. Consequently, their farming decisions will not be affected as much as commercial farmers, who have benefited from the price support system. Subsistence farmers will, however, benefit from direct income support payments, because the payments are based on the amount of land historically planted in eligible commodities (71).

In addition to NAFTA, Mexico has entered into free trade agreements with Chile (1991), with the Latin American Association for Integration (ALADI), and with the Central American Common Market (MCC). Trade with Chile grew by 50 percent between January and June 1992, and by 30 and 32 percent with ALADI and MCC, respectively, during the same period. Mexico is also pursuing negotiations with Colombia and Venezuela, as well as with the Asian-Pacific Economic Cooperation group.

European Union

Like the United States, the EU has been struggling in recent years to change agricultural policies and practices that, while arguably relevant decades ago, do not reflect the realities of the 1990s. In the 1950s, when the Common Agricultural Policy (CAP) was instituted, European agriculture employed a full 26 percent of the total workforce (compared with 12 percent in the United States in 1955), and was a highly relevant part of the European economy. Nonetheless, the living standards of European agricultural workers lagged behind those of urban workers, just as European farming practices and technology lagged behind those of other parts of the world (9). Consequently, the original objectives of the CAP were to increase agricultural output through capitalization and technology, to improve the living standards of agricultural producers, stabilize agricultural markets by protecting the sector from international price fluctuations, ensure an abundant supply of food, and establish reasonable prices for consumers.

After three decades, the objectives of the CAP have largely been met—but the environment in which the European agricultural sector operates has become qualitatively different. The EU has changed from a net agricultural importer to the world's second-largest exporter. Income gains have been realized, but have not been equally distributed: the top 25 percent of farmers, who make 80 percent of all agricultural sales, have gained the most. Overall, in real terms, farm income unambiguously slipped between 1970 and 1992 (84). As in the United States, operators of small and medium-size farms began to rely more and more on income generated off the farm. European agriculture's contribution to the region's GNP has decreased, and the agricultural labor force has shrunk even as production and productivity have increased. "While in the first years of the EU's existence there was a general consensus to pursue policies aimed at increasing production and economic returns, the last decade has witnessed the growth of a more socially oriented political agenda. The latter is a part of the emerging support for environmental, food, and natural resource issues" (9).

These new concerns are largely unrelated to production issues of the past. Although commodity organizations resisted any reform in the CAP, they came under increasing pressure from other politically organized groups, both within and outside agriculture, to support changes. The greatest impetus for change, however, was the financial burden imposed by current policies under the CAP, which, all told, absorb 70 percent of the EU budget. Generally, reform proponents wished to reduce agricultural supply, diversify production to target changing consumer demands, target assistance to low-income farmers, decouple assistance from the amount and type of commodity produced, and bring agricultural policies more in line with environmental policies.

In 1992, the EU adopted CAP reforms designed to steer the agricultural sectors of members away from price supports and toward land area payments over a period of four years. The reforms apply to all products incorporated in the common market organization, with the exception of sugar, wine, fruit, vegetables, pig meat, poultry meat, and eggs. The three main reforms include lower price supports, land area payments that are decoupled from production levels, and arable land set-aside schemes that offer farmers compensation payments. In the case of land area payments, a switch from a per-unit to a per-hectare payment effectively ensures that payment is not based on yield (36). Under this new regime, cereal crop intervention prices were lowered by about 33 percent. To compensate for the lower price, farmers who produce more than 92 tons of grain are required, and paid, to set aside 15 percent of their arable area for five years. The land set-asides apply to the total cultivated area, rather than to each crop area, and the area payment rises in line with price support reductions. For milk, milk products, and beef, reform measures decreased intervention prices by 2.5 to 15 percent (45).

In 1993, the EU Commission moved to make the set-aside program more flexible by offering three-year rotational set-asides, under which 18 percent of arable land would be taken out of production; and a combination of rotational and nonrotational set-asides, under which a minimum of 20 percent of arable land would be taken out of production. One proposal suggests that farmers be allowed to set aside more than the minimum required amount of arable land (although such a scheme might pose budgetary problems). According to the Food and Agriculture Organization (FAO), less than 1 percent of the then-EC's arable land was covered under the set-aside program in its first year of operation (15). In 1993, set-asides in the 12 EU member states were estimated to be 13.1 percent. The figure for the United Kingdom was 15.6 percent; for France, 13.3 percent; for Germany, 15 percent; and for the Netherlands, 5.3 percent (3).

Canada

Like most of the countries covered here, Canada saw its PSE decline in recent years. This phenomenon is, however, less a reflection of explicit policy than of changing levels of support for individual commodities. Support has remained relatively low for livestock, moderate for poultry, and high for dairy products. Support for grains and oilseeds, on the other hand, has varied. It increased markedly after the mid- 1980s, when international price competition grew fiercer (73).

Generally, Canada's agricultural tariffs are low, averaging 2 percent or less in 1991 for grains, fresh meat, and dairy products. Almost 95 percent of Canada's agricultural tariff lines are bound, which means that it cannot increase any of them without first going through official GATT procedures and addressing comments from other countries. Canada also maintains quantitative border restrictions for dairy, eggs, and poultry, as well as restrictions on domestic production. The country's dairy sector is oriented toward local markets and meeting domestic demands; its wheat sector, conversely, is geared toward exports. Canada is one of the world's toughest competitors in international grain markets. The goal of its wheat support programs is to moderate the effects of fluctuations in world markets on domestic prices and incomes. But transportation subsidies and price supports have not fully offset the losses in income stemming from a continuing drop in world cereal prices (21,22). Total financial assistance to agriculture amounted to 57 percent of Canada's agricultural GDP from 1988 to 1989. As with the EU, public assistance has not prevented Canadian farm incomes from declining. They have been decreasing since 1988.

United States

In 1991, the United States exported $37.6 billion worth of agricultural goods. The agricultural trade surplus represented 0.3 percent of GDP in 1992, compared with 0.9 percent in 1980. The top three agricultural export markets for the United States are Japan, Canada, and Mexico, which accounted for 21.12, and 8 percent, respectively, of U.S. exports in 1991 (74). (See table 6-4.) The principal U.S. export crops include feed grains, soybeans. live animals and meat, wheat, cotton, vegetables, and fruits. The United States controls 77 percent of the world export market for corn and 73 percent for sorghum. (See table 6-5.) The most competitive grain market it faces is the world wheat market. The United States controls 31 percent of that market; Canada and the EU control 22 percent each. Because the United States' share of world production or world trade of grain, meat, oilseeds, and sugar is so large, U.S. farm policies have a major impact on world export markets for these and competing products.

TABLE 6-4: Top Ten Export Markets for U.S. Agricultural Products, 1991

Country	Billions on dollars
Japan	7.74
Canada	4,41
Mexico	2,88
S. Korea	2,16
Former U.S.S.R.	1,76
Taiwan	1.74
Netherlands	1.56
Germany	1,13
U.K.	0.88
Spain	0.86
Total	37.60

SOURCE: U.S. Department of Agriculture, Foreign Agricultural Service, *Foreign Agriculture* (Washington, DC December 1992)

The United States continues to use high tariffs to protect sugar and tobaccos, and it employs import quotas to protect dairy products, cotton, peanuts, sugar, and beef and veal. Wheat, coarse grains, rice, oilseeds, cotton, tobacco, and dairy are still heavily subsidized and therefore have significant competitive advantages in the world market. Nevertheless, the PSEs for both wheat and barley decreased by more than 40 percent between 1987 and 1992. The PSEs for dairy, beef, and sugar also fell, between 12 and 21 percent; the rice PSE, in contrast, increased 8 percent. Income support payments decreased by 55 percent during the same period, and input assistance transfers dropped by 59 percent (73). The decline in input

TABLE 6-5: Production and Trade Information for 1990-1991

Production		Export		Import	
Country/commodity	Percent of world production	Country	Percent of world exports	Country	Percent of world imports
Corn					
u s	42	us.	77	Japan	28
China	20	China	12	U. S. S. R.*	18
Brazil	5	Argentina	6	Taiwan	9
EU	5	Canada	0.3	EU	6
Mexico	3	EU	0.2	Mexico	3
Argentina	2				
Sorghum					
U.S.	33	U.S.	73	Japan	45
India	27	Argentina	17	Mexico	38
China	8	Australia	3	Taiwan	1
Mexico	5				
Argentina	3				
Australia	2				
Wheat					
U S. S. R.*	18	U.S.	31	Other	42
China	17	Canada	22	U. S. S. R.*	16
EU	14	EU	22	China	10
U.S.	13	Australia	13	Japan	6
India	8	Argentina	5	Brazil	3
Canada	6				
Australia	3				
Rice					
China	36	Thailand	32	Others	66
India	22	U.S.	18	Brazil	7
Indonesia	9	EU	8		
Thailand	3	Australia	4		
Japan	3				
Oilseeds					
U.S.	28	U.S.	47	EU	37
China	15	Argentina	15	Japan	19
Brazil	8	EU	10	Mexico	6
Argentina	8	Canada	8		
EU	5	Brazil	6		
Canada	3				
Cotton					
China	24	U.S.	34	Others	41
U.S.	18	U. S. S. R.*	9	Japan	12
U. S. S. R.'	14	Australia	6		
Brazil	4				
Beef and Veal					
Us.	22	EU	24	Us.	31
U. S. S. R.*	18	Australia	22	Japan	15
EU	17	Us.	12	EU	13
Brazil	7	New Zealand	9	U. S. S. R.*	8
Argentina	5	Argentina	8	Canada	6
		Brazil	6	Brazil	5

(continued)

TABLE 6-5 (Cont'd.): Production and Trade Information for 1990-1991

Production		Export		Import	
Country/commodity	Percent of world production	Country	Percent of world exports	Country	Percent of world imports
Dairy Products**					
EU	42	EU	45	U. S. S. R.*	20
U.S.	19	New Zealand	20	Japan	19
U. S. S. R.*	11	Australia	11	EU	13
New Zealand	3	U.S.	6	Us.	10
Australia	2	U. S. S. R.*	1	Australia	2

*Former U.S.S.R

**Dairy products Include butter, cheese, and nonfat dehydrated milk

SOURCE: U.S. Department of Agriculture, Foreign Agriculture Service, *Foreign Agriculture* (Washington, DC December 1992) and *Dairy: World Markets and Trade,* FD-1-95 (Washington, DC: April 1995)

assistance transfers is accounted for mainly by decreases in credit subsidies for operating and real estate loans, and for commodity loans through the Commodity Credit Corp.

Agricultural export promotion programs received 75 percent of the total spent in fiscal year 1991 on promoting all U.S. exports. Approximately 21 percent of U.S. agricultural export revenues are supported by government subsidies. (See chapter 3.) These programs include the Marketing Promotion Program, the Public Law 480 food aid program, the GSM-102 and 103 export credit programs, the Export Enhancement Program (EEP), and the Dairy Export Incentive Program. Under EEP, 74 percent of U.S. exports of barley, and close to 60 percent of wheat and frozen poultry exports, were subsidized in 1993. Since 1991, the United States has spent more on EEP and has targeted three new countries under the EEP wheat program. It has also applied an antidumping duty on New Zealand kiwi fruit of 100 percent, which has made it impossible for the fruit to be imported, and has tightened quotas on meat imports. Federal outlays for domestic milk support fell to $125 million in 1993, down from $2 billion in 1987. Subsidies still exist, however, and are often 75 percent higher than the subsidized item's export price (24).

The Agricultural Adjustment Act of 1933 continues to restrict the imports of dairy products, peanuts, cotton, and sugar. Imports of sugar above the tariff quota were subject to a tariff of roughly 76 percent, which was reduced 13 percent in 1992. Under the provisions of the GATT Uruguay Round, the United States will replace the current tariff-rate quota for sugar with a tariff equivalent of 17 cents per pound, which will be reduced 15 percent (the minimum required) by the year 2000. Tobacco imports face a high tariff of 46 percent, and U.S. manufacturers are required to use 75 percent domestically grown tobacco in their products.

Japan

Japan is the largest net agricultural importer in the world. The United States supplies 36 percent of Japan's agricultural imports, including 87 percent of its corn imports, 73 percent of soybean imports, 53 percent of wheat imports, 42 percent of fresh fruit imports, and 55 percent of beef and veal imports. Japan is the world's largest foreign market for U.S. farm products, accounting for 20 percent of all U.S. agricultural exports. Despite its large agricultural purchases, however, Japan is under pressure from its international trading partners to open its markets to a wider variety of agricultural imports, especially high-value, processed products.

Japan's agricultural policies of the past half-century were greatly influenced by the country's experience of food shortages during and after World War II. In 1943, Japan enacted the Staple Food Control Act, which put domestic distribution of major food items, including rice and rice trade, wheat, and barley, under state control. Food shortages continued until the late 1950s, when Japan's agricultural sector began to recover. Japan attained self-sufficiency in rice by the late 1960s, and by the 1970s it began yielding surpluses.

To achieve its agricultural policy objectives, Japan uses a combination of border measures such as quotas and tariffs, direct price supports to producers, and subsidies on agricultural inputs. Rice, wheat, and barley farmers receive most of the agricultural assistance provided by the government. Until recently, rice accounted for 50 percent of Japan's agricultural policy costs. Japan maintains supply controls on milk and rice, and quasi-governmental bodies, such as the Livestock Industry Promotion Corp., operate price support regimes for certain dairy products and sugar, as well as price stabilization schemes for beef and pork. The government also offers deficiency payments for feeder calves, soybeans used for food, and milk for processing.

Agricultural policies were modified to adjust to Japan's rapid economic growth between the 1950s and 1970s. During this period, much of the agricultural labor force shifted to the manufacturing sector, and agriculture as a percentage of GDP decreased from 9 to 3 percent (66). Between 1961 and 1992, the labor force in agriculture decreased from 26 to 12 percent. To shield the agricultural sector from the effects of displacement, the Japanese government enacted the Agricultural Basic Law in 1961. The law aimed to reduce the disparity between urban and rural living standards, to raise productivity by increasing farm sizes, and to tailor production to the changing demands of Japanese consumers.

In the early 1980s, Japan began a further, gradual reform of its agricultural policies in response to growing rice surpluses. The Rice Paddy Agriculture Establishment Program, through production quotas and financial incentives for planting alternative crops to rice, has succeeded in diverting about one-third of all paddy land to other crops, such as soybeans and wheat—crops that were being imported in large numbers—and vegetables. It has also succeeded in reducing rice production by one-fifth. Until 1984, the government also subsidized the sale of rice in the world market and sold it cheaply for use in industrial processes and for feed. Support prices for rice were reduced in 1987, 1988, and 1990, and government control of rice marketing has loosened to the extent that private firms may purchase directly from farmers instead of through the Government Food Agency (23).

Although the economic importance of rice in Japan has been declining, it is still high, accounting for 47 percent of the gross value of agricultural production in 1960, and 29 percent in 1989. Seventy-five percent of Japanese farm households produce rice and 56 percent market rice. A significant decline in rice self-sufficiency—that is, a move toward importing more rice—would have far-reaching consequences (87). More than 50 percent of Japan's farmers are over 60 years old, and they could have a particularly difficult time adjusting to a more liberal rice market. On the other hand, only one-fifth of farm households are financially dependent on farming. For the remaining four-fifths, farming accounts for only 15 to 20 percent of household earnings.

The average household income of full-time farmers lags behind that of part-time farmers and urban households. A recent policy proposal by the Ministry of Agriculture, Forestry, and Fisheries, dubbed New Directions, targets government support to full-time farmers (70).[8] New Directions also advocates maintaining border measures, to ensure that Japan maintains its self-sufficiency in producing various foodstuffs. The fundamental structure of the staple food control system and the production quota system for rice remain essentially unchanged in the New Directions proposal.

[8] Recent legislation includes the Act for the Improvement of the Basis of Farm Management (1993). This legislation supports the policy proposals of the Basic Direction of New Policies for Food, Agriculture, and Rural Areas (1992) of the Ministry of Agriculture, Forestry, and Fisheries.

Most of Japan's high tariff rates are imposed on agricultural and food products, rather than on manufactured products. However, in the GATT Uruguay Round, Japan agreed to convert its import barriers on agricultural products (except for rice) to tariffs, and to reduce its bound tariffs by an average of 36 percent over a six-year period beginning in 1995. There is to be a minimum reduction on each tariff line of 15 percent (79). Japan also agreed to allow rice imports equivalent to 4 percent of domestic consumption in 1995 and equivalent to 8 percent of consumption in 2000.

One group of Japanese economists at the University of Tokyo's Agriculture Department found that open trade in rice would cut Japanese consumers' demand for domestic rice by two-thirds (87). In this case, Japan's self-sufficiency rate would fall to 33 percent. Over the next decade, the government would like its rice sector to increase paddy productivity and become more internationally competitive. Japanese farmers currently cannot compete because key rivals such as Thailand and the United States have larger (100 to 200 times larger) and more efficient farms, and/or significantly lower wage rates. Until Japanese farmers can become more competitive, the government will continue to protect them.

Japan's PSE fell 10 percent between 1985 and 1990,[9] reflecting a decline in government support for all commodities. Lower producer prices accounted for most of the reduction. Border measures remain the government's strongest form of support.

Argentina

Until recently, Argentina was the only country of those considered in this chapter to rely on its agricultural sector for resources to support industrial development. But in 1991, Argentina introduced policies to deregulate, decentralize, and privatize its economy, in an effort to reduce these transfers. Export taxes— including export taxes on all agricultural products except unprocessed oilseeds—were eliminated and exchange rate regimes reformed (20). Such policy changes decreased the implicit tax on the agricultural sector by 66 percent between 1985 and 1992 (73). Along with other trade liberalization measures, they should also help reduce the costs of agricultural production in Argentina and increase demand for its products abroad. Argentina's agricultural sector consequently has a great opportunity for expansion, mainly through productivity gains but also through increased acreage. Investment, especially in infrastructure, is extremely important for future growth.

Agriculture and agri-based products have often constituted 70 to 80 percent of Argentina's total export earnings. Oilseeds, fats, and oils are the country's most valuable export commodities. Because two-thirds of the world's annual trade in wheat is exported with subsidies, credit guarantees, or as aid, Argentina has had difficulty competing in the world wheat market in past years. Its share in the world wheat market has declined by 50 percent since the 1950s.

Australia

Australia is one of only two countries examined here whose PSEs rose since 1985. (See table 6-3.) Australia's higher PSE does not, however, reflect new policies advocating increased government support for agriculture. In fact, the overall level of support for agriculture in Australia has remained relatively low and essentially stable since 1982. The PSE jump stems in part from a large payment made to the country's wheat producers in 1986, which was triggered by a drop in world wheat prices below Australia's guaranteed minimum price (GMP). It was the first GMP payment since 1973. In 1989, a new Wheat Marketing Agreement deregulated the domestic wheat market, and the country's embargo on sugar was replaced with a tariff-rate quota (73).

Although Australia's PSE has not changed significantly, some major policy changes toward less

[9] Using an average from the years 1985 to 1987 as a base.

government intervention are taking place. Estimates indicate that the PSE decreased by 4 percent and 6 percent in 1991 and 1992, respectively (51).

Taiwan

Once based on agriculture, Taiwan's economy has come to be firmly rooted in industry. In the early 1970s, agriculture accounted for 30 percent of Taiwan's GDP; by 1991, it represented only 4 percent. Taiwan is currently a net importer of agricultural goods: primarily bulk commodities, such as feed grains, and intermediate agricultural products.

Between 1953 and 1968, Taiwan's agriculture sector was heavily taxed to supply the bulk of the resources necessary to fuel a new industrial sector. In addition, to ensure that it would have the amount of rice it deemed necessary for economic stability, the government controlled rice production, marketing, and trade. Subsequently, however, the government shifted from taxing agriculture to subsidizing it. Restrictive border measures initially intended to protect scarce foreign exchange now served to protect the domestic agricultural sector (34). Then and now, trade barriers in the form of very high tariffs, an import-licensing system, and import bans hinder imports of most agricultural products, including rice, wheat, sugar, tobacco, milk, and beef.

In the 1950s, agriculture represented about 90 percent of the value of all exports from Taiwan, but from 1960 to 1964, its share dropped to 62 percent. From 1985 to 1989, the figure was 7 percent. Farm crops account for 44 percent of the value of agricultural production; fisheries, 28 percent; and livestock, 27 percent (60). Rice production accounts for 40 percent of the country's crop acreage and approximately 80 percent of all government expenditures on crops (33). Although the total area planted in rice has been decreasing since 1965, productivity per hectare has increased over the years, due in part to increased chemical inputs, improvements in rice varieties, and improved irrigation practices (33). Prices for rice, corn, sorghum, soybeans, and sugarcane are artificially supported through programs designed to ensure supply and increase farm income. Domestic prices for these products are much higher than world market prices.

Although Taiwan's agricultural sector benefits from price supports, high tariffs, and import bans, production levels for most crops, except vegetables, are declining (74). The government abandoned unlimited purchase of rice in 1976 because it lacked sufficient storage space and funds. Further, to reduce production to a level that would meet domestic demand only, the government introduced control measures in 1984 that included riceland diversion, rotation, and set-aside programs. In contrast, hog and pork production has been increasing, although the environmental problems presented by porcine waste, as well as economic pressures, may adversely affect the sector in coming years.

Taiwan applied to join GATT in 1990. Two years later, the GATT ruling council voted to grant Taiwan observer status and to accept its membership application for review. As a result, Taiwan is trying to make its agricultural and trade policies consistent with the GATT requirements (74). The country's government is currently considering two reform measures: direct income supports for farmers, with the gradual elimination of supports for production; and incorporation of the hitherto unpaid costs of production—such as environmental degradation—into the cost of agriculture. Taiwan has asserted its commitment to reducing tariffs by up to 20 percent on 483 items in 1994 (79). However, since the government abandoned martial law in 1987, farmers have become an outspoken political force, and they strongly support agricultural subsidies. Politically, it will be difficult for Taiwan to eliminate or reduce these subsidies enough to conform with GATT requirements.

The increase in Taiwan's percentage PSE is not due to any explicit change in government policy. It can be attributed in part to the appreciation of Taiwan's currency since 1985, changes in world prices, and changes in domestic prices. Taiwan offers high guaranteed purchase prices for all of the commodities used in calculating its PSE, and, as noted above, maintains restrictive border measures.

Taiwan's Council of Agriculture, through its 1991-1997 Agricultural Adjustment Plan (AAP), intends to ensure domestic food security, make the highly protected agricultural sector more market-oriented, achieve zero agricultural growth through 1996, move toward a more environmentally sound agricultural policy, and increase rural incomes from 70 to 80 percent of urban incomes. The plan has successfully reduced production of subsidized agricultural products such as rice and sugar, but it does not dismantle the system of artificial support for agriculture. AAP has increased public awareness of what changes the nation must expect as it pursues GATT membership (6).

Brazil

In 1990, Brazil initiated major reforms in its economic and agricultural policies making them more open to world markets. It lifted almost all nontariff barriers to trade and export controls, reduced tariffs, revamped its monetary system, and initiated a privatization program. Specific reforms of note have included the Brazilian government's moves to decrease the country's average tariffs from 32 to 14 percent over the period 1990 to 1993; lift restrictions on soybean imports and exports, as well as on grain imports; and relinquish its 25-year control of wheat marketing.

Brazil generally supports domestic market crops (rice, wheat, corn) more than export market crops (soybeans, beef, poultry). As a result, some Brazilian producers have a difficult time competing internationally. Poultry, for example, which receives a 6.2 percent subsidy in the United States, is subjected to a 7.6 percent tax in Brazil.

ENVIRONMENTAL PROVISIONS IN AGRICULTURAL POLICY

Environmental awareness in most countries increased during the 1960s and 1970s. Although the approaches to environmental problems and the philosophical underpinnings of government action varied, most governments had at least some environmental legislation and regulations in place by the mid to late 1980s. The implementation, enforcement, and effectiveness of these policies and regulations has differed from country to country.[10]

Most countries have been slow to incorporate the agricultural sector into their environmental policies, programs, and regulations. Except in the case of product and safety standards, producers have faced few restrictions in choosing inputs and technology, and have felt relatively free to alter their landscapes to increase production. In the United States, for example, return flows from irrigation are not covered under the Clean Water Act, and pesticide programs have focused on chemical production rather than chemical use by farmers (88). However, many countries now recognize that they have achieved, or are currently achieving, the objectives of agricultural policies at the expense of the environment. (See chapter 4 for a discussion of how agricultural practices affect the environment.) Countries now recognize than many agricultural practices and established agricultural policies are in conflict with their more recently developed environmental objectives. As they contend with environmental problems stemming from agricultural practices, governments are generally pursuing more restrictive agroenvironmental agendas. This trend reflects changing environmental values, greater scientific understanding of the links between agricultural practices and environmental quality (15), and earlier efforts to tackle point source pollution that were not fully successful in achieving the desired environmental quality. Among the items on the new agendas are programs to align economic signals with environmental goals, such as policies that attempt to decouple financial support from agricultural product prices and reduce incentives to use agrichemicals. Regulations and programs that restrict fertilizer

[10] As noted earlier, it is important to be cautious when attempting to compare the agroenvironmental policies of different countries. The country's state of environmental health must be known in order to determine whether action is even warranted, and the degree of implementation and enforcement should be addressed as a means of determining the efficacy of policies. This chapter examines trends in agroenvironmental policies only. It does not systematically address the aforementioned issues.

and pesticide use to protect water quality, wetlands, and wildlife habitats, as well as preserve the countryside for recreational uses, are also on the rise.

In Canada, the Sustainable Agricultural Initiative of the 1990 Green Plan addresses the need for the agriculture industry to operate in a more "environmentally rational" way. The Canadian Green Plan allows the federal minister of agriculture, the provinces, and the private sector to enter into initiatives that include measures to halt soil degradation, develop shelterbelts,[11] provide stable supplies of clean water, make agriculture and wildlife more compatible, manage pollution, protect and use genetic resources, limit greenhouse gas emissions, and improve energy efficiency on farms (25). The country's Farm Income Protection Act requires periodic assessments of the environmental impacts of all programs implemented under the act (22). Environmental impact assessments have become an important feature of Canadian agricultural policy. The act also permits insurance to be withheld, restricted, or enhanced for the purpose of protecting the environment.

Financial assistance programs, integrated pest management programs, and research on "biorational" products and soil conservation are all contributing to Canada's desired transition to sustainable development. Nonetheless, institutional barriers still present a primary obstacle to the transition (39). The Canadian Wheat Board's system of quota allocations, for instance, is tied to "improved" land—a stipulation that encourages farmers to bring marginal land, which is often particularly susceptible to degradation, into production. In addition, payments made through the Western Grain Stabilization Act are tied to past output, which again encourages farmers to focus on high output regardless of how sustainable their practices are (81).

The EU has taken several steps over the past decade to formally address environmental problems resulting from agricultural practices. It is integrating environmental concerns into the formulation of agricultural policy, modifying existing agricultural policies to reduce their negative environmental impacts, and employing economic incentives for farmers to use environmentally benign land management practices. The EU began incorporating measures into the CAP to restrict production and promote environmental quality in the early 1980s, and the 1992 CAP reforms have continued this effort by incorporating a package of environmental measures associated with agricultural practices. The measures are all voluntary and offer farmers annual payments for implementing certain land management practices (32). The measures include:

- creating new environmentally sensitive areas (ESAs). These are designated areas in which farmers may voluntarily abide by certain management practices in return for compensation.
- allowing the public to use ESAs.
- creating new nitrogen sensitive areas (NSAs). These are areas where nitrate concentration in groundwater exceeds 50 mg/l.[12]

Other practices, such as preserving salt marsh habitats and moorland vegetation, and using organic farming methods, are also eligible for financial assistance. The funds for these measures represent about 5 percent of total CAP expenditure.

The United States is also broadening its agroenvironmental agenda to include, in addition to soil conservation, water quality improvement and protection of wildlife habitat. (See chapter 4.)

Most agroenvironmental problems fit into the following three categories identified by an FAO

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[11] A shelterbelt is a row or rows of trees or shrubs that help protect crops from storms and protect soil from wind erosion.

[12] The EU and the United States use different methods for measuring nitrate levels. The EU measures the level of nitrate concentration by measuring the whole NO_3 molecule; the United States measures the level of nitrate concentration by measuring just the nitrogen (N) component of the molecule. The U.S. drinking standard of 10 mg/l is roughly equivalent to the European standard of 50 mg/l (50 mg/l of nitrate measured by the EU method is equivalent to 11 mg/l of nitrate measured by the U.S. method.) (41)

TABLE 6-6: Threatened[a] Mammals, Birds, and Fish (late 1980s)

Country	Mammals		Birds		Fish	
	Species known[b]	Percent threatened	Species known	Percent threatened	Species known	Percent threatened
Canada	193	6.2	514	3.3	1,066	4.4
U.S.	466	10,5	1,090	7,2	2,640	2.4
Japan	188	7.4	668	8.1	207	10.6
Australia	349	12.3	760	3.4	3,592	0.4
New Zealand	78	2.6	282	15.2	1,061	0.8
France	115	50.4	353	37.4	75	22,7
Germany	94	39.4	237	28.3	70	70
Netherlands	66	28.8	170	22.4	34	79,4
U.K.	44	NA	520	28.3	341	2.6

[a]The classification of "threatened" refers to the number of species considered endangered or vulnerable. The definitions are applied with varying degrees of rigor in Member countries, although international organizations such as the International Union of Concerned Scientists and the OECD are promoting standardization

[b]The number of species known does not necessarily reflect the number of species in existence.

SOURCE: Organization for Economic Cooperation and Development, *Environmental Data Compendium1993* (Paris, France 1993).

conference on the socioeconomic aspects of environmental policies in European agriculture (15):

- pollution and contamination of soil, water, air, and food, resulting from increased use of agrichemicals and excess amounts of livestock effluents;
- deterioration of the quality of natural resources, including soil, water, forests, and traditional rural landscapes;
- reduction in wildlife species and habitats, and loss of biological and genetic diversity.

The extent and severity of these problems varies not only among but also within countries, as the environment ability to absorb waste and contaminants is not uniform. Agricultural practices detrimental to the environment in one area maybe environmentally benign in another.

The next sections look at agroenvironmental policies, programs, and trends in several countries. The sections specifically address habitat destruction, as well as water contamination from nitrate fertilizers and livestock, as examples of common agroenvironmental problems. Both the problems and policy responses are outlined.

Protecting Wildlife Habitat from Intensive Farming

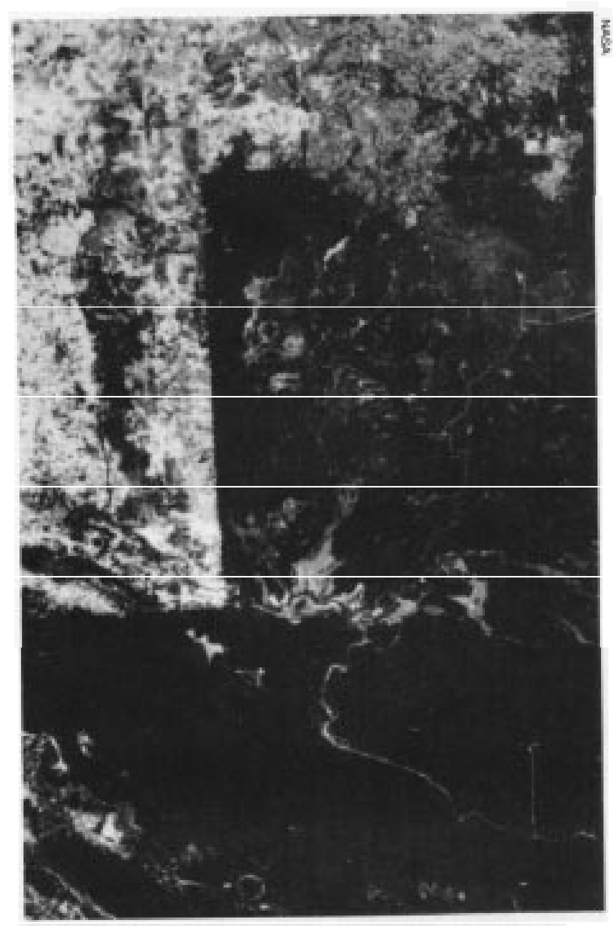
The relative numbers of threatened or endangered species diverge dramatically among the countries examined in this chapter. While mammals represent a fraction of those species, they provide a point of comparison. Canada has the lowest percentage of threatened or endangered mammals (6.2 percent) and France the highest (50.4 percent) (52). In the United States, 10.5 percent of known mammal species are considered threatened or endangered. (See table 6-6 for other countries and species.) In 1994, the number of threatened and endangered species in the United States exceeded 900. Very few studies have measured the loss of habitat due to fragmentation or the edge effect created as a result of agricultural practices. 13

[13] Although some habitats may not be completely converted to farm use (or urban or industrial use), they can be fragmented so greatly that they no longer suit the life-cycle needs of some species. Fragmentation also creates more edge environments (where distinct habitats meet). Although edge environments are normally rich in diversity, the species found in them differ from those found in interior habitats.

As discussed in chapter 4, any modification to land or water resources changes their capacity to sustain plants and animals. Destruction or even modification of habitat by agricultural practices can lead to a reduction in species abundance and/ or species diversity. Globally, of species extinctions since 1600, fully 36 percent of those that resulted from known causes are attributed to habitat destruction or modification (86). About one-third of the federally listed threatened or endangered species in the United States are associated with agriculture. (See Chapter 4.) In West Germany, 581 plant species are listed as “declining”: 173 because of farmland drainage, 89 because of herbicides, and 56 because of excess nutrients from fertilizers (38).

Converting wetlands to agricultural use is a primary example of disturbing wildlife habitats and damaging natural resources. Until recently, no country had specific policies to protect wetlands. In fact, several had incentives encouraging their “destruction” or their “improvement” to productive uses. With greater scientific understanding of the complexity of wetland ecosystems came an increased appreciation for their functions and, subsequently, greater pressure to protect them. (Aside from acting as habitats for fish, waterfowl, invertebrates, and other wildlife, wetlands absorb urban runoff and flood waters, filter pollutants, improve water quality, and offer recreational opportunities. The value of these wetland functions is often hard to quantify.) However, several governments' agricultural policies, existing simultaneously with wetland protection policies, indirectly encourage the conversion of wetlands to other uses. For example, price supports and program benefits based on cultivated acreage encourage farmers to cultivate on marginal lands as well as wetlands. As a result, before any concerted efforts to protect them were made in any country, a large percentage of the world's wetland areas had been converted to other uses or had been significantly degraded.

Wetlands constitute about 6 percent of global land area. During this century, wetland losses have been very high and wetland quality—in terms of species diversity and certain functions—has diminished. Many authorities classify wetland ecosystems as among the world's most threatened environmental resources (50). The loss of wetlands, as discussed above, can be attributed to the conversion of wetlands to agricultural, industrial, commercial, and residential uses. Degradation of wetland quality can be attributed to air and water pollution, as well as water supply diminution. Between 1980 and 1990, Canada lost an estimated 23 percent of its wetlands; France, 8.5 percent; and West Germany, 22 percent. Although similar information was not available for the United States, New Zealand, or the Netherlands for this time period (52), federal data show that



This aerial Landsat image shows how agricultural expansion can severely effect native habitats. In this area of southern Mexico (left), most of the tropical forest has been cleared to make way for cropland. By contrast, neighboring Guatemala (right), has retained much of its forests.

about half of the original wetlands in the conterminous U.S. have been lost, with 80 percent going to agricultural conversions. Indeed, a comprehensive picture of the state of the world's wetlands does not exist, because very few wetlands are assessed or monitored. In the United States (excluding Alaska), for example, only 4 percent of the nation's wetlands have been assessed, and no state is currently operating a comprehensive wetland-monitoring program (77).

Concern about the agricultural impacts on the environment was voiced early in the United Kingdom, with the construction of industrial farm buildings in the 1950s. The dramatic decline of some bird species, which was linked to synthetic pesticides; the loss of different habitat types such as wetlands, hedgerows, and moorlands; and the destruction of nature conservation sites increased public awareness of agriculture's impact on the environment. In 1984, the Nature Conservancy Council published a survey of habitat loss and concluded that since the mid-1950s the nation had lost 95 percent of its lowland herb-rich grasslands, 50 percent of its ancient woodlands, more than 60 percent of its lowland raised bogs, and 33 percent of all its upland grasslands, heaths, and mires (84). In the United Kingdom, wetland loss due solely to agricultural land use and practices was estimated at 150,000 acres per year during the 1970s and early 1980s. A strong, well-organized rural conservation movement developed in Britain, and the whole system of agricultural support, rather than the activities of individual farmers, came under attack as the root cause of undesirable environmental changes.

Since 1949, England has had a provision to designate Sites of Scientific Special Interest (SSSIs). Yet, even though it became evident that changing agricultural and forestry practices were damaging these areas, the SSSI program had no authority to protect them from intensive agricultural activity. In 1981, the government passed the Wildlife and Countryside Act to offer further protection. This act specifically authorized regulation of farming practices such as plowing, draining, and pesticide and fertilizer application to protect these designated areas. Even with this new authority, though, the SSSI program failed to protect valued habitats—in part because it was complex, and because it was administered by the Department of the Environment (DOE) rather than the Ministry of Agriculture, Fisheries, and Food (MAFF). The two agencies did not work together. "A commonly noted shortcoming of countryside management and the conservation regulation of farming practices was that they typically involved the conservation agencies swimming against the tide of agricultural support" (84). Thus, while MAFF was offering financial inducements to farmers to increase productivity and output, DOE was offering incentives for farmers not to increase farming intensity (84). One study of the United Kingdom found that in the early 1980s, some 80 percent of the payments to farmers to refrain from intensive production were essentially subsidies to forgo other subsidies to produce more intensively (15).

Although MAFF was slow to collaborate with other environment agencies or the environmental community on concerns about the impact of farming on the environment, the farming lobby actively engaged in discussions with the environmental community. However, the farm lobby insisted on maintaining agricultural autonomy and stressed the need for informal and voluntary policies to address environmental issues related to agriculture (84).

SSSIs were the precursors to ESAs. In 1984, the United Kingdom proposed modifying the CAP to create ESAs. Within ESAs, farmers would be encouraged to farm using traditional and/or environmentally benign methods. About the same time, MAFF worked to replace grant programs that had been criticized for promoting environmental degradation with a grant program that encouraged planting hedges, repairing traditional walls, planting broad-leaved shelterbelts, and hiring consultants to provide landscaping advice. In 1986, the Agriculture Act required agriculture ministers to balance "the conservation and promotion of the enjoyment of the countryside, the support of a stable and efficient agricultural industry, and the economic and social interests of rural areas" (84).

Many species that are dependent on wide expanses of native forest or grassland habitats cannot thrive in fragmented, farmland habitats. Population trends in many bird species offer clues about the effects of agricultural practices on native wildlife.

The EU Council of Ministers passed the New Structures Directive as Article 19 of Council Regulation 797/85 on Improving the Efficiency of Agricultural Structures. This article allows member states to introduce special national schemes that encourage farming practices favorable to the environment in ESAS. In England in 1985, ESAS became the first "specifically environmental measure to be supported directly from the agricultural budget." In 1987, it was agreed that such schemes could receive up to 25 percent support from the EU budget (84).

In 1987, the first ESAS were established, followed by additional designations in 1988, 1993, and 1994. Farmers in areas designated as ESAS may enter into a voluntary agreement to adopt a certain set of agricultural practices in return for annual compensation. There are usually different options from which the farmer may choose, each associated with a different payment scheme. Management stipulations usually include some combination of restrictions on fertilizer use; prohibitions on the use of pesticides and herbicides; restrictions on livestock densities; restrictions on the installation of drainage schemes or fencing; and requirements to maintain walls, barns, and hedges. Farmer participation has been enthusiastic. By the end of 1987, fully 100,000 hectares of land in England were entered into the program, representing 87 percent of the land targeted for ESA designation. All of the 1988 ESA designations were renewed at the end of five years. In 1993, the United Kingdom had 1.7 million hectares in the program; the proposed area for 1994 is 2.2 million hectares.[14] However, farmers who choose not to participate in the ESA program may still receive subsidies for environmentally damaging practices, reflecting the persistence of conflicting policies (84). Germany, the Netherlands, and France also have ESA schemes.

In the United States, the Conservation Reserve Program (CRP), introduced in the 1985 Farm Bill, was specifically designed to achieve conservation goals by encouraging farmers to withdraw highly erodible or environmentally sensitive lands from crop production for a period of 10 years, in return for annual payments. By 1989, a total of 8 percent of U.S. cropland was enrolled in the program. As a result of the 1990 amendments to the Farm Bill, new rules for CRP operation placed greater emphasis on water quality improvement and public wellhead protection as criteria for accepting land into the program (67).[15] Thirteen percent of the land contracted into the program in March and July of 1991 came from conservation priority area watersheds such as the Chesapeake Bay and Great

[14] The success of the ESA program, compared with the SSS prograrn, has been addributed to several factors: the ESA scheme is administered by agricutural officials rather than conservation officials, participation is voluntary, it is less complicated to participate in the program, and it is less restrictive (84).

[15] Protecting aquatic habitat could require more intensive action such ss undoing the structural changes to hydrologic systems that were often put in place to accommodate agricultural needs. (See chapter 5, box 5-l.)

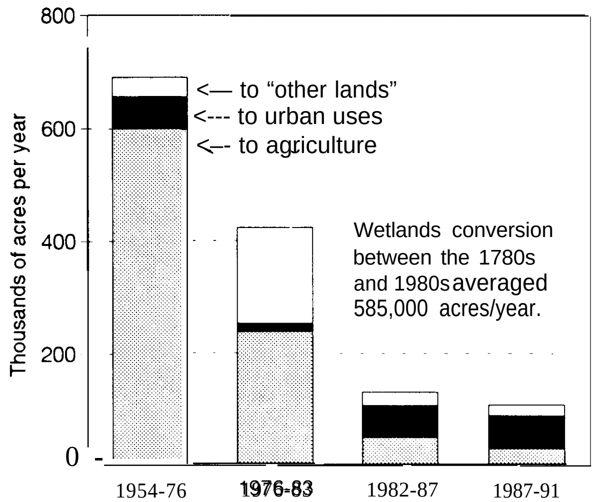
Lakes regions. The 1990 act mandated that a minimum of 16.2 million hectares be enrolled in the CRP, up from the 14 million hectares of 1985(14). Although the CRP was not conceived, nor is it managed, as a program to protect wildlife, it has resulted in improved habitat for wildlife. Generally, the negative effects of modern agriculture on countryside amenities and wildlife habitat are of greater concern in the EU than in the United States and receive a great deal of attention from policy-makers in some EU countries (2).

In addition to the CRP, the 1990 act created the Wetlands Reserve Program (WRP), which provides payment and cost-sharing assistance to farmers who agree to return previously farmed or converted wetlands to healthy wetland condition. The WRP is designed to incorporate up to 405,000 hectares of wetlands and protect them by easement for 30 years. The Swampbuster program concentrates on protecting existing wetlands by making farmers who convert wetlands without a permit ineligible for USDA program benefits. The Swampbuster program and a similar program for soil erosion, Sodbuster, were the first steps taken in the United States to move from completely voluntary programs to programs that, although still voluntary, had financial repercussions if not followed.

In the United States, agriculture is no longer the primary cause of wetland losses (figure 6- 1). Yet, of the wetlands lost over the past two centuries, 80 percent has been attributed to the conversion of inland wetlands to agricultural uses. Agricultural conversions of wetlands have slowed since the mid-1980s. However, an estimated 2.11 million hectares of wetlands are still considered prime land for agricultural production.

Between 1950 and 1975, the United States lost wetlands at an estimated rate of 400,000 to 500,000 acres per year. The rate decreased to 250,000 acres per year after 1975. In the mid-1980s, wetlands of the conterminous states covered approximately 103 million acres (of nearly 2 billion acres) (13). The U.S. Fish and Wildlife Service estimates that 50 percent of the wetlands that existed during colonial times in the lower 48 states are now gone. Roughly 5 percent of the lower 48 states is currently covered by wetlands, and about 45 percent of Alaska is comprised of wetlands.

FIGURE 6-1: Conversion of U.S. Wetlands, 1954-1991



SOURCE: Thomas E Dahl, *Wetland Losses in the United States 1780's to 1980's* (Washington DC U S Department of Interior, Fish and Wildlife Service, 1990)

Roughly 75 percent of remaining U.S. wetlands are located on private land. Increasing loss of these wetlands led the U.S. government to embrace a policy goal of no net loss (NNL) of wetlands in 1989.

U.S. wetlands are not protected by any single federal law or regulation. Several programs at all levels of government play a limited role in protecting wetlands. To influence the behavior of landowners, federal programs have used a combination of direct payments, removal of various federal subsidies, and a mitigation banking system.[16] State and local programs have concentrated on zoning and land use controls.

Canada contains one-quarter of the world's wetlands. As in the United States, roughly 70 percent of all Canadian wetlands are located on private land, and most of the remaining wetlands on federal land are located in the northern territories. Since 1800, an estimated 20 million hectares—14 percent of Canada's total wetland base—have been drained or lost to other functions. Millions more hectares have been seriously degraded or are at imminent risk. The loss is felt in every region: 65 percent of the Atlantic coastal salt marshes are gone, more than 50 percent of the potholes in the central prairies have been lost, and 70 percent of the Pacific estuary marshes are gone or degraded (26). In Canada, as in the United States, there is no single federal law protecting wetlands. The federal policy on wetland conservation commits all federal departments to a goal of NNL of wetland functions on federal lands and waters, and in areas affected by the implementation of federal programs. In areas where wetland loss has been severe, no further loss of remaining wetlands is allowed.

Six challenges are listed for the NNL policy, including defining NNL, encouraging dialogue among all relevant stakeholders, and spreading the costs of achieving NNL among those who benefit:

> . . .[T]he goal does not imply that individual wetlands will in every instance be untouchable or that the no net loss standard should be applied on an individual permit basis—only that the nation's overall wetlands base reach equilibrium between losses and gains in the short run and increase in the long term. (37)

In the province of Ontario, wetlands are generally depleted in the southern portions of the province. No provincial legislation specifically addresses wetlands or expressly requires their protection. However, the policy generally advocates no loss of wetland function or wetland area of provincially significant wetlands in the Great Lakes-St. Lawrence region, and no loss of wetland function of provincially significant wetlands in the Boreal region. It also encourages the conservation of other wetlands throughout Ontario. Some wetlands are protected under the Fisheries Act, the Canada Wildlife Act, and provincial legislation creating parks and wildlife areas. The Conservation Land Tax Reduction Program and the Conservation Lands Act offer tax rebates to owners of wetlands meeting certain criteria if they leave their wetlands in their natural state (29).

The North American Waterfowl Management Plan (NAWMP), a joint venture between the United States and Canada, was formally initiated in 1986, with the goal of restoring North American waterfowl numbers to their mid-1970s level. One objective of NAWMP is to encourage agricultural producers to set aside land for waterfowl habitat (to maintain potholes and native uplands). However, NAWMP has primarily been concerned with the effects of management on waterfowl populations. "The effects of agricultural prices, government programs, et cetera, on private land-use decisions that affect the availability of wetlands have largely been ignored" (80).

A 1988 study using surveys of farmers in southeastern Saskatchewan indicated that government support programs contribute to wetland depletion in western Canada. The model looked at four price scenarios for wheat. A price of \$2.50/bu represents no government support; \$3.50/bu represents intermediate support; \$4.50/bushel represents the baseline; and \$5.50/bushel represents a high level of support. The percentages of wetlands converted under each scenario are 57 percent, 72 percent, 81 percent, and 86 percent, respectively (80). In addition, payments to farmers to maintain

[16] A wetlands mitigation banking program was developed to compensate for unavoidable wetland loss due to development activities such as road construction. The program allows for development as long as plans include off-site creation of wetlands, wetland restoration, or wetland enhancement of other sites. The program is administered primarily under the Clean Water Act and includes the participation of federal agencies, nonprofit organizations, and private entities (64).

waterfowl habitat are higher than they would have to be in the absence of grain-support payments.

Fertilizer Consumption and Environmental Impacts

In addition to soil conservation, one of the first agriculture-related environmental issues to receive broad attention was the nitrate pollution of groundwater and surface water. The primary sources of nitrate pollution include nitrogen fertilizers and animal manure from intensive animal husbandry (72). In humans, high levels of nitrate have caused respiratory failure in infants and may be linked to stomach cancer. Nitrate leaching into ground and surface waters is a principal causes of eutrophication.[17] The effects of these inputs on the environment depend on management practices, soil composition, topography, and climate. In some circumstances, nitrate could leach into groundwater rapidly, and in other circumstances leaching could take decades (12,72,75). Although the United States and the EU have set the consumption level of nitrate for humans at 50 mg/l, surface water quality can be adversely affected by nitrogen at levels as low as 14 mg/l (31,40).

Research has clearly shown agriculture to be the greatest source of nitrate contamination in ground and surface waters, with concentrations increasing three-fold (in forested or prairie areas) to 60-fold (in agricultural areas) (31). Except for the Netherlands, fertilizer consumption per hectare increased in all of the countries examined in this chapter between 1979 and 1991, even though the general trend is toward a decrease in total fertilizer consumption. Japan's consumption of fertilizer has been waning since 1986, when it reached a high of 434 kg/ha. Likewise, Mexico's fertilizer consumption reached a peak in 1987 with 75 kg/ha and has been decreasing since. During the 1980s, fertilizer subsidies were about 40 percent, but Mexico phased them out in 1991 (l). Brazil has decreased consumption steadily since

TABLE 6-7: Fertilizer Consumption (Nitrogen, Phosphate, Potash)

Country	Fertilizer consumption (in 1,000s of metric tons) 1979 and 1991		Fertilizer consumption (kg/ha) 1979 and 1991	
Argentina	130	166	3	6
Australia	1,214	1,164	25	27
Brazil	3,567	3,148	27	53
Canada	1,808	2,074	18	47
France	5,905	5,683	242	289
Germany[a]				
FR	3,597	2,873	421	247
NL	1,713	1,765	320	
Netherlands	694	561	728	581
U K	2,235	2,450	252	317
Japan	2,344	1,839	365	387
Mexico	1,134	1,559	25	63
New Zealand	546	362	888	934
U.S.	20,941	18,428	80	100

[a]FR=Federal Republic, NL= New Leader

NOTES Japan's fertilizer consumption has been decreasing since 1986 when it reached a high of 434 kg/ha. Fertilizer consumption in Mexico and Brazil has also been decreasing Mexico's fertilizer consumption reached a peak in 1987 with 75 kg/ha and has been decreasing since then Brazil has also decreased consumption steadily since 1987

SOURCES: Food and Agriculture Organization of the United Nations, *Country Tables* (Rome, Italy 1993), Food and Agriculture Organization of the United Nations, *Yearbook, Fertilizer,* vol. 41 (Rome, Italy 1991)

1987. In 1991, Argentina and Australia consumed the lowest amounts of fertilizer: 6 kg/ha and 27 kg/ha respectively (table 6-7). Argentina's low application rates of fertilizer are partly due to its rich soil. However, soil degradation is one of the country's main agroenvironmental problems and, as it continues, farmers may resort to using more fertilizers. The highest consumption of fertilizer in 1991 was found in New Zealand and the Netherlands, with 934 kg/ha and 581 kg/ha, respectively. The United States consumes 100 kg/ha (table 6-7).

Nitrate Pollution in the EU

Nitrate pollution became a serious concern in the 1980s---especially in the EU, which has one of the world's highest rates of fertilizer use and its high-

[17] Eutrophication is a process through which excess nutrients, principally phosphorous and nitrogen, cause algae blooms, which in turn deplete the dissolved oxygen levels in a body of water.

est livestock densities. In 1980, the EU passed a Drinking Water Directive that set the maximum allowable concentration of nitrate in groundwater at 50 mg/1. It did not legislate any way to enforce this level. The standards were to be met by 1985, but Ireland is the only member state that has done *so* (72).

In the former West Germany, 5 percent of drinking water tested exceeds the standard, and in France, 2 percent of drinking water tested exceeds the standard. In the Netherlands, the average nitrate concentration found 30 meters below sandy soils is 106 mg/l, more than twice the standard (72). At the EU level, of the total amount of nitrogen applied, 57 percent is residual. Germany, France, and the United Kingdom account for more than 65 percent of the total residual nitrogen of the EU. However, the Netherlands has the highest residual nitrogen levels of all EU countries (These statistics incorporate data from the EC-10[18] only) (72). About 45 percent of the nitrogen from fertilizers applied to the soils in the Netherlands is more than crops need. In addition, nitrogen from manure (principally from pigs) amounts to 1.5 times the amount of nitrogen from fertilizer, giving the Netherlands a total residual nitrogen level of 77 percent of the total amount applied. Part of the problem is that manure is considered something to dispose of, rather than a production input that could offset the use of manufactured fertilizers. To address the problem, the Netherlands is introducing some of the most stringent legislation concerning nitrate contamination among the EU countries.

For the EU as a whole, wheat and course grains account for 45 percent of nitrogen use. For the Netherlands, the nitrate problem stems principally from livestock production (2). Until recently, efforts to control the negative environmental impacts of livestock production focused on regulating the amount and method of manure spreading and improving manure storage. These efforts

Nitrate pollution in surface water and groundwater can result from the leaching of fertilizer or manure used on cropland. Livestock wastes, improperly stored, area significant source of nitrate as well as pathogens that degrade water quality

are not sufficient, because they do nothing to decrease the amount of total manure produced. Policies to restrict livestock numbers and to tax feed manufacturers are now being introduced in the Netherlands (table 6-8) (15).

Various farming practices can be employed to limit the amount of nitrate reaching ground and surface waters. These efforts can be put in three categories: "attempts to match nitrogen availability to plant growth requirements[, which] include plant tissue testing, crediting for the nitrogen content of manure, use of slow release fertilizers, and split applications of nitrogen; practices that physically block nitrate movement such as storing manure in lined lagoons and using vegetative filter strips around field edges; [and] changes in farming practices such as using conservation tillage, planting a postharvest cover crop, and using crop rotations that minimize the need for nitrogen" (48). Generally, governments have used voluntary programs and subsidies to diminish agriculture's negative impact on the environment. Persistent problems have forced some governments to consider other methods.

[18] The EC-10 refers to the original members of the European community, now the European Union: Belgium, Denmark, France, Greece, Germany, Ireland, Italy, Luxembourg, the Netherlands, and the United Kingdom.

TABLE 6-8: Sources of Nitrogen from Manure in Selected EU Countries, 1986 (1,000 Metric Tons)

Country	Dairy	Beef	Pigs	Layers	Broilers	Sheep	Total
Germany	349	651	549	25	102	42	1,717
France	416	1,043	275	33	299	327	2,393
Netherlands	149	176	249	19	143	16	752
U.K.	208	604	217	25	254	511	1,819
Total	1,555	3,408	1,851	142	1,064	1,625	9,645

SOURCE U S Department of Agriculture, Economic Research Service, "The EC Nitrate Directive and Its Potential Effects on EC Livestock Production and Exports of Livestock Products, " by Dale Leuck in *Environmental Policies: Implications for Agricultural Trade,* edited by John Sullivan, USDA/ERS-FAER #252, Washington, DC, June 1994

The EU recognized the limitations of member country programs in meeting the drinking water standard and the discrepancies among countries in implementing the necessary programs to meet the standard. As a result, in 1991, after two years of debate, the EU Council of Environmental Ministers passed the Nitrate Directive. The purpose of the Nitrate Directive is to prevent nitrate levels in water from exceeding the standard of 50 mg/l. Under the directive, regions with excessive amounts of nitrate are classified as vulnerable zones, and farmers residing in those areas must adhere to "codes of good practice." The codes include limits on livestock densities, rules concerning the storage and application of slurry, limits on application rates for chemical fertilizers, rules concerning appropriate fertilizer application, and record keeping (40). Member states may take different approaches to incorporating these principles into practice. Regions outside vulnerable zones are also encouraged to follow the codes of good practice. The minimum standards for the code are set at the EU level, but member countries may set standards that are more strict. Countries with vulnerable zones have until 1995 to establish plans to reduce their nitrate levels to the 50 mg/1 standard or below. They then have four years to implement their plans. Enforcement of the directive relies in large part on citizens groups to make formal complaints if farmers do not comply with the directive. Farmers in member states such as the United Kingdom. Germany, and the Netherlands, which have stronger and more active citizens' groups than other EU members, will be held to strict compliance standards. Farmers in other counties may not be monitored so closely (40).

The Nitrate Directive was designed to place the burden of reducing residual nitrogen on reducing livestock numbers. In the Netherlands, for example, farmers could eliminate residual nitrogen if they reduced their livestock numbers by 65 percent and cut fertilizer use by 28 percent. The necessary livestock reductions are not as drastic for the EU as a whole. Pig production would have to be reduced by 11.7 percent, dairy stock by 7.8 percent, and beef by 4.8 percent (72). The impacts of these reductions on the ability of member countries to remain self-sufficient are shown in table 6-9. The EU as a whole becomes just less than self-sufficient in pork, poultry meat, and eggs. The Netherlands become less than self-sufficient in beef and veal, butter, pork, and poultry meat. The largest drop in the Netherlands comes with a decrease in egg self-sufficiency, from 339 to 119 percent.

Because a significant portion of EU agricultural products is exported, any policy change that affects production could also affect world trade. For the EC- 10, the Nitrate Directive could lead to a decline in beef exports of 50 percent and a decline in dairy exports of 34 to 100 percent. The EU would become a net importer of pork and poultry (table 6-9) (72). Given these projections, the Nitrate Directive should spur research and development as demand grows for new technology to improve the quality, storage, and application of manure. In addition to the Nitrate Directive, other EU policies

TABLE 6-9: Percent Self-Sufficiency: 1991-1992 Average and Estimated Under the Nitrate Directive

Country	Beef/Veal	Butter	Cheese	Dry milk	Pork	Poultry meat	Eggs
Netherlands[a]							
1991-1992	194	174	294	27	257	205	339
Estimated	68	61	103	9	90	72	119
EC-1 O							
1991-1992	110	111	109	132	105	108	102
Estimated	105	102	100	121	93	97	92

[a]For example, in 1991-1992, the Netherlands self-sufficiency rate for cheese was 294 percent, meaning that they met 100 percent of their domestic demand and then could export the remainder Under a fully implemented Nitrate Directive the Netherlands would still meet their domestic demand for cheese, but would have much less available for export, 3 percent.

SOURCE: U.S. Department of Agriculture, Economic Research Service, "The EC Nitrate Directive and its Potential Effects on EC Livestock Production and Exports of Livestock Products, " by Dale Leuck in *Environmental Policies Implications for Agricultural Trade,* edited by John Sullivan, USDA/ERS-FAER #252, Washington, DC, June 1994

that were not implemented specifically for environmental reasons—such as a new superlevy equal to 115 percent of the target price for milk produced beyond a quota----could help to decrease nitrate levels.

The Netherlands

Dutch farmers, who export about 65 percent of their total output, generally use more chemical fertilizers than farmers in any other country, In 1991, Dutch farmers used 581 kg/ha of chemical fertilizer (18). Such intensive farming has caused environmental problems, most notably nitrate contamination of groundwater. The government realized in the early 1980s that the problem could be addressed only by requiring significant changes in the agricultural sector. The current policy holds that export expansion cannot interfere with national environmental priorities.

Well before the Nitrate Directive was passed, the Netherlands was struggling with the environmental problems posed by excessive manure. In 1986, the government implemented a three-phase program to address the nitrate issue. The first phase (1987-1990) aimed at stabilizing the problem by setting standards for the maximum amount of manure that could be applied per hectare. The initial standards were set high enough that the current level of manure could be disposed of, but set strict regulations on the expansion of existing farms or the establishment of new farms. The second phase (1991-1994) gradually tightened the maximum application standards. Phase three (1995-2000) further tightens the standards to balance application of fertilizer and manure against what the Dutch environment can absorb (46). Farmers are initially allowed to meet fertilizer reduction goals in any way they choose. However, if they have not met the goals by the specified time, they are subject to a tax on input use (68). In addition, 200,000 hectares of land have been retired in a program analogous to the CRP in the United States. An estimated 90 percent of Dutch farmers comply with the regulations of these programs.

Through the Fertilizer Act, the government has set up a national manure bank that allows farmers who have too much manure to transport it to other parts of the country that are below the manure standard. Large-scale manure-processing plants are also being developed to process manure in pelted form for export. In 1988, the Netherlands established a tax on livestock feed manufacturers. The revenue from the tax goes toward financing education and research on manure disposal (15).

Germany

Germany's Council of Environmental Advisors considers nitrate contamination of the groundwater one of the most serious environmental problems attributed to agriculture although, as in other countries, the problem remains regional. In 1987, a full 46 percent of the nitrate problem stemmed from agricultural practices. In 1983, a total of 800 out of the 6,000 water supply facilities exceeded the 50 mg/l nitrate level, up from 129 in 1979. Until recently, nitrate pollution was addressed at the supply end: aquifers were closed, new boreholes were drilled, and polluted water was mixed with clean water. Now, the chief policy objective is to reduce nitrate pollution from agricultural sources, although these measures are not yet well implemented (58).

Under a 1986 drinking water ordinance and the Act on Water Resource Management, local authorities are to determine which water collection areas need protection. Standards for agricultural practices can be set within these areas. If farmers have to employ practices more stringent than those stipulated in the act in order to meet its standards, and if, consequently, their incomes drop as a result of lower yields or higher production costs, the act provides compensation for them. Designated protected areas range from between 3 and 40 percent of a region. Germany's Fertilizer Act, instituted in 1989, contains an amendment that allows fertilizer use only if "the code of good agricultural practice is followed," which means that fertilizer application must be determined by considering the nutrient requirement of crops, the nutrient content of the soil, and the productivity of the soil. The Act to Support Rural Farming prescribes livestock densities. If these are exceeded, farmers may lose certain subsidies. The government also plans to enact a Fertilizer Application Ordinance, which will fulfill the requirements of the EU Nitrate Directive and further define "good agricultural practices."

Nitrate Pollution in the United States

A national survey of rural drinking water wells in the United States found that 3 to 6 percent of them contained nitrate concentrations above the drinking water standard of 1Omg/l established by the U.S. Environmental Protection Agency (see footnote 11). Elevated nitrogen levels have been detected in some groundwater or surface water of all 50 states (31,48), although not all of these cases exceeded EPA standards. Still, in Nebraska, an estimated 20 percent of drinking water wells exceed the standard, and in southeastern Pennsylvania 28 percent exceed the standard (48). Cases of local or regional nitrate problems are not uncommon across the United States.

Surface water draining from areas of intensive cropland or livestock operations regularly contains elevated nitrate levels. In the San Joaquin Valley, one of the most intensive agricultural areas in the country, nitrate levels regularly exceed 1Omg/1 (47). Groundwater under agricultural lands also tends to exceed this nitrate standard nearly 3 times more often then water beneath any other land use (see chapter 4). Besides posing a problem for drinking water, nitrate carried in surface water flows promotes eutrophication in rivers, lakes and estuaries, thus impairing their ability to serve as aquatic habitat (see chapter 4).

The United States does not have a basic policy on nitrate pollution equivalent to the Nitrate Directive of the EU. Rather, the nitrate problem is addressed, or could potentially be addressed, in sections of the Safe Drinking Water Act (SDWA), the Clean Water Act (CWA), the Toxic Substances Control Act (TSCA), and the Coastal Zone Management Act (CZMA). However, the provisions in these acts for addressing the nitrate problem are mostly voluntary, and there is no federal implementation of nitrate policy.

Under the CZMA Reauthorization Amendments of 1990, the 29 states and territories with federally approved coastal zone management programs are required to develop enforceable policies and mechanisms to implement nonpoint source pollution control programs. Six nonpoint source management measures address a range of related issues: erosion and sediment control, small and large confined animal facilities, pesticide management, grazing management, irrigation management, and nutrient (including nitrate) management. The nutrient management measure requires all farms in the coastal zone to:

> . . . develop, implement, and periodically update a nutrient management plan to: 1) apply nu-

trients at rates necessary to achieve realistic crop yields, 2) improve the timing of nutrient application, and 3) use agronomic crop production technology to increase nutrient use efficiency (76).

States are required to develop their plans for EPA and NOAA (National Oceanic and Atmospheric Administration) approval by July 1995. After approval, they have three years to fully implement their plans. If states choose not to develop plans, they will forgo federal funding under section 319 of the CWA, which establishes a national program to control nonpoint sources of pollution,[19] and section 306 of the CZMA. Some states, such as Texas, may choose to incur the loss of federal funding. Others, like Pennsylvania, have redefined their coastal zone boundaries to exclude areas with high manure supplies.[20] Because there is no federal implementation of these nutrient management measures, there is no further recourse to require states to develop meaningful plans.

USDA also coordinates voluntary and educational programs on preventing nutrient problems with cost-share funding provided by the Agricultural Conservation Program (ACP) run by the Consolidated Farm Services Agency (CFSA) and the educational programs of the Natural Resources Conservation Service (NRCS). These programs are discussed in chapter 4.

Air Quality

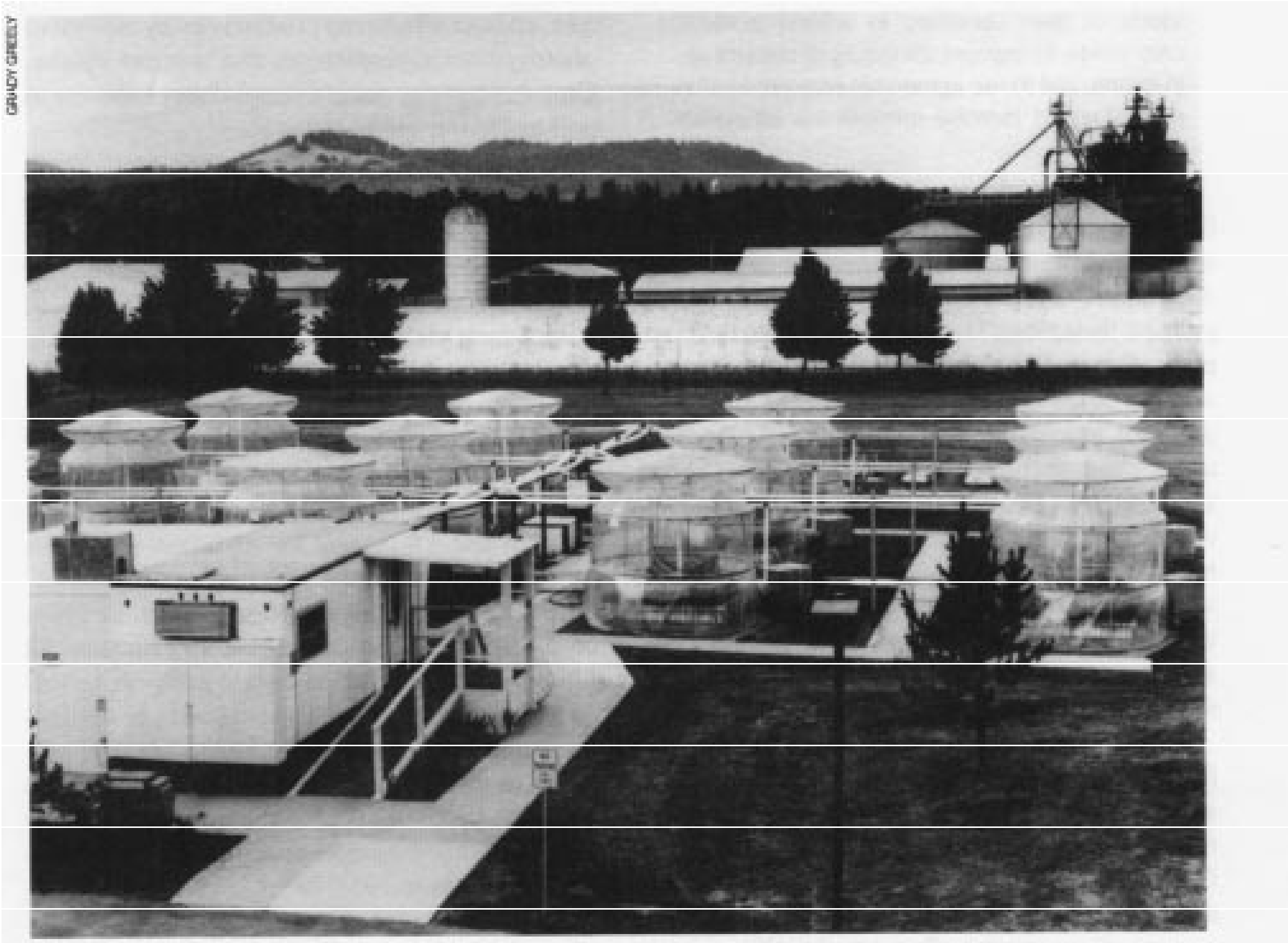
In addition to acting as a generator of environmental damage, agriculture is also the recipient of damage from other sources. External environmental impacts on agriculture include natural disasters such as floods and droughts; conversion of farmland to urban uses; global climate change; and air, water, and soil pollution from urban and industrial sources (55). This section singles out air pollution and its impact on agriculture.

Pollution generated in urban centers can be transported to agricultural areas through wind and rain, and can affect crop productivity by inhibiting photosynthesis, respiration, and nutrient uptake. Crop damage can occur through direct exposure to pollutants or from the indirect effects of pollution. One study looking at the regions of eastern North America, Europe, and eastern China and Japan found that 9 to 35 percent of the world's food crops are exposed to ozone concentrations (i.e., increased ozone levels) above a threshold shown to reduce crop yields by 5 to 10 percent. The study suggests that the current loss of the world's cereal and other crop yields due to ozone is 3 percent (11). Another study of the eastern United States estimated that a 10-percent reduction in ozone levels would result in yield increases of 4.1 percent for corn and 3.0 percent for soybeans, and that a 10-percent reduction would result in a yield increase of 3.4 percent for corn (82,83). In 1984, crop damage due to ozone cost an estimated $2 billion (65). "On a national scale in North America and western Europe, current losses of agricultural production due to air pollutants are small relative to other factors, but local impacts on sensitive crops may be substantial" (7). Yield losses averaged over the state of California from ambient ozone in 1984, for example, were an estimated 20 to 30 percent for sensitive crops such as grape, cotton, citrus fruits, beans, and onions. In the Los Angeles basin, where ozone concentrations are among the highest in the world, production of many sensitive crops has been abandoned (7).

In the United States, air quality standards are determined and regulated through the Clean Air Act of 1970 (amended in 1977 and 1990). The U.S. approach to regulation is generally more centralized than that of Canada, France, the Netherlands or Japan, for example, but less centralized than that of Taiwan or China. The federal government is responsible for setting the minimal, binding national ambient air quality standards (NAAQS), approving and overseeing state programs, and providing financial and technical as-

[19] Personal communications, Roberta Perry, EPA, Oct. 26, 1994 and Andy Manale, EPA, Dec. 7, 1994.

[20] Personal communication, Andy Manale, EPA, Dec. 7, 1994.



Poor air quality can reduce crop productivity Here, federal researchers study how exposure to ozone effects various crops.

sistance to states. The states are responsible for developing and implementing programs that will result in compliance with federal standards. The Clean Air Act of 1990 broadens the scope of regulations pertaining to ozone and particulate to include smaller sources that were previously exempt. In addition to NAAQS, the act provides for the Prevention of Significant Deterioration (PSD) Program, which aims to maintain air quality in areas already below the NAAQS.

Although the Clean Air Act of the United States has brought notable improvements in air quality, many areas do not yet comply with the act. In 1994, a total of 92 areas (more than 400 counties) violated the ozone standard, even though ambient ozone levels declined by 14 percent between 1980 and 1989. And although ambient concentrations of SO_2 decreased by 24 percent between 1980 and 1989, a total of 44 counties were classified as "nonattainment" areas for SO_2 in 1994 (65,78). NOx emissions[21] increased by 8 percent between 1970 and 1989, largely due to increased fuel consumption. NOx emissions have also increased in several other countries, including Canada, Japan, and Germany (table 6-10).

21 Nitrogen oxide, NO, and nitrogen dioxide, NO_2, are collectively referred to as NOx. Likewise, SOx refers to the sulfur oxides, including sulfur dioxide or SO_2.

TABLE 6-10: Trends in NO_2, SO_2, and Suspended Particulate Matter Concentrations in Selected Cities

Trends of $N0_2$ Concentration in Selected Cities

Nation	City	1980	1984	1985	1986	1987	1988
Canada	Montreal	O 027	0,022	0.021	0.020	0.023	0.024
	Vancouver	NA	0.024	0022	0023	0.021	0023
U.S.	New York	0.032	0.032	0.031	0.030	0.033	0.033
	Los Angeles	0.047	0,043	0044	0.044	0.037	0039
France	Pans	NA	NA	NA	NA	NA	NA
Germany	Berlin	0.017	0,019	0.020	0019	0022	0022
	Frankfurt	0026	0023	0.021	0022	0025	0.026
Netherlands	Amsterdam	0.019	0.020	0022	0025	0028	0028
U.K.	London	0031	0,040	0.031	0034	0.037	0.033
Japan	Tokyo	0034	0031	0.030	0030	0033	0.033
	Kawasaki	0027	0.033	0031	0033	0033	0033

Trends of Suspended Particulate Matter in Selected Cities

Nation	City	1980	1984	1985	1986	1987	1988
Canada	Montreal	0.014	0.006	0.007	0.006	0.005	0005
U.S.	New York	0.013	0.014	0.013	0.012	0.012	0011
	Los Angeles	0.008	0.005	0.004	0.004	0.004	0004
France	Pans	0.031	0.019	0.018	0.017	0.016	0012
Germany	Berlin	0.032	0.023	0.023	0.023	0.026	0018
Netherlands	Amsterdam	0.009	0.007	0.006	0.005	0.005	0005
U.K.	London	0.025	0.017	0.015	0.016	0.014	0.014
Japan	Tokyo	0.018	0.010	0.009	0.009	0.009	0007
	Kawasaki	0.014	0.011	0.010	0.009	0.010	0010

Trends of $S0_2$ Concentration in Selected Cities

Nation	City	1980	1984	1985	1986	1987	1988
Canada	Montreal	0.082	0,057	0.048	0051	0053	0045
	Vancouver	0068	0035	0.043	0040	0044	0037
U.S.	New York	0056	0,050	0050	0046	0048	0.050
	Los Angeles	0090	0085	0.084	0078	0.081	0.084
France	Paris	0.051	0,047	0049	0046	0046	0029
Germany	Berlin	0098	0120	0124	0.125	0095	0090
	Frankfurt	0.073	0.034	0.068	0058	0071	0061
Netherlands	Amsterdam	0066	0.065	0.063	0053	0045	0044
U.K.	London	0.021	0.018	0.015	0015	0.016	0019
Japan	Tokyo	0.048	0,052	0.053	0058	0.059	0.053
	Kawasaki	NA	0.046	0,042	0.047	0051	0047

NOTE: The readers should be cautious when interpreting this table, especially because of large differences in the number of monitoring sites and method of monitoring among countries A comparison between two or more cities IS not advisable, a comparison of trends IS preferable

NA=Not Available.

SOURCE: Government of Japan, Environment Agency, *Quality of the Environment in Japan, 1992,* Organization for Economic Cooperation and Development, *Environmental Data Compendium 1991* (Paris, France, 1991)

Canada's air quality is similar to that of the United States, but its approach to regulation is much more decentralized. Under the Canadian Clean Air Act of 1971, the federal government has the authority to set nonbinding guidelines. Binding air quality standards and the regulations necessary to achieve them are generally set by the provincial governments (one exception is that the federal government sets standards for automobile emissions from new vehicles). Although levels of SO_2 and total suspended particulates (TSPs) have been decreasing, more than half of all Canadians are exposed to unhealthy amounts of smog, ozone, NOx, and volatile organic compounds (VOCs) (25,27). Between 1979 and 1987, the amount of ozone in Canadian air increased by 7 percent.

Japan has invested heavily in industrial stationary source pollution control technology and has established one of the most sophisticated air pollution monitoring networks in the world, partly as a result of serious pollution problems in the 1960s and increased public outcry.[22] Compared with other OECD countries, Japan now has the lowest per-capita and per-unit GDP emission levels of SOx (see footnote 21) and NOx. Japan established environmental quality standards (EQS) in 1967 under the Basic Law for Environmental Pollution for SO_2, NO_2, CO, PM-10, and photochemical oxidants.

Nonetheless, air quality problems in Japan persist. NOx emissions decreased 21 percent between 1970 and 1989, largely due to improvements in combustion technology and the introduction of catalytic converters on motor vehicles. However, because the transportation sector continued to grow, and the EQS for NO_2 were relaxed in 1978, NOx emissions have increased since 1985.

The European Union has established air quality directives for SO_2, NO_2, suspended particulates, and lead. Member states must comply with pollutant levels deemed generally acceptable, and must strive to achieve the more stringent guidelines. Member states must also draw up improvement plans for areas that exceed the acceptable levels. The directive addressing SO_2 incorporates a "standstill principle" similar to that of the PSD in the United States, under which air quality is not allowed to deteriorate significantly even in areas well below the maximum allowable limits for these pollutants (30).

Germany, France, and the Netherlands are generally in formal compliance with the air quality directives of the European Union. The United Kingdom has a a good legal record but still needs to address specific issues that remain unresolved, such as the exemption of Northern Ireland from many of the regulations, the sulfur content of gas and oil, and vehicle emissions. The Netherlands has one of the EU's best records for implementing the directives; Germany, France, and the United Kingdom have experienced relatively few problems. The directives addressing vehicle emissions and emissions from industrial plants have been especially difficult for member states to comply with (30).

Several countries participate in both bilateral and multinational agreements. For example, the United Nations Economic Commission for Europe Long-Range Transport of Air Pollutants addresses NOx and will address SO_2 and VOC; the U.S.-Canada Air Quality Agreement, signed in 1991, commits both countries to specific targets and timetables for reducing acid deposition precursors; a joint communiqué signed by the United States and Mexico in 1990 calls for a plan to reinforce border cooperation on a range of environmental issues, including air quality (65). Table 6-11 shows how various countries' air quality standards compare with those of the World Health Organization (WHO). National U.S. standards are

[22] Environmental awareness grew in Japan during the late 1950s and early 1960s, when several widespread diseases—Minimata disease, Itaiitai disease, and Yokkaichi asthma—were associated with the manufacture of the chemical acetaldehyde, the mining of cadmium, and the operation of petrochemical plants. The Japanese government eventually instituted one of the world's most advanced compensatory programs for the victims of pollution. The program was abolished in 1988 (8).

TABLE 6-11: Comparison of Country Air Quality Standards to WHO Air Quality Standards

	NOS (1hr)	SO2 (24hr)	Ozone (1hr)
Countries with Air Quality Standards More Stringent than WHO Standards	Brazil EU Japan[a]	Japan[b]	Brazil Japan U.S. (CA)
Countries with Air Quality Standards Less Stringent than WHO Standards	Argentina Taiwan U.S. (CA)	Taiwan Brazil EU Us. U.S. (CA)	Argentina Us.

[a]24-hour standard used
[b]1-hour standard used

SOURCE: UNEP/WHO, *Earthwatch Global Environment Monitoring System Urban Air Pollution* in *Megacities of the World,* Blackwell Reference, 1992

set below WHO standards for $S0_2$ and ozone, although California's standard for ozone is set above the WHO standard. Only Japan air quality standards are set higher than the WHO standards for $N0_2$, $S0_2$, and ozone.

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Opportunities for Redesigning Policies for Agriculture, Trade, and the Environment

7

The previous chapters have demonstrated that global integration, expanding and changing world agricultural markets, and heightened environmental concerns are defining new policy challenges and opportunities for the United States. These trends manifest themselves in global markets that demand growing amounts of value-added agricultural products; an emerging environmental agenda that extends beyond traditional conservation concerns; and an expanding research agenda that increasingly emphasizes environmental protection, food safety, marketing and trade, and profitable, yet environmentally sustainable agricultural systems.

Unfortunately, federal policies and programs affecting the agricultural sector have not changed sufficiently to address these new concerns. Indeed, they conflict with the new developments in significant ways. They promote production of bulk commodities and hinder possible opportunities for U.S. farmers in fast growing, value-added export markets. They divert major resources to soil conservation while other issues of significance—water quality, wildlife habitat, and soil quality—remain relatively neglected. Almost two-thirds of agricultural research funding is devoted to increasing farm output, but more output will mean more federal subsidies to export surplus crops, and still more federal funds to "idle" land to control surpluses.

As the United States moves toward the year 2000, and as continuing budget pressures constrain traditional subsidy solutions, government must explore innovative approaches to these dilemmas. Furthermore, tensions between agricultural policies and trends in both trade and environmental spheres create costly inefficiencies. Seeking complementary and mutually reinforcing policies for agriculture, trade, and the environment could not only

lessen budget pressures but also help ensure that the nation's policies are oriented to the future, not anchored to the past.

Seeking complementarity would involve:

- synchronizing domestic trends with global forces,
- targeting program resources on priority areas,
- encouraging development of technologies that serve multiple objectives, and
- using markets or market-like mechanisms wherever possible.

This chapter presents policy options for agriculture, trade, and the environment that illustrate how policies and institutions can be complementary rather than in conflict. As the United States heads into the 21st century, such complementarity could have a key influence on the role and standing of U.S. agriculture in an ever-expanding global economy. Moreover, seeking complementarity among agricultural, trade, and environmental policies will permit the United States to seize the opportunities of global market expansion while protecting and advancing domestic goals related to environmental quality as well as the competitiveness of the agricultural sector. Options to modify existing programs and legislation, or to introduce new programs and legislation that pursue complementarity for agriculture and trade, agriculture and the environment, and trade and the environment are examined in turn.

POLICY OPTIONS FOR AGRICULTURE AND TRADE

A paramount message of this report is that today's farm programs no longer serve the needs of the agricultural economy and the nation. Farm programs are costly, many work at cross purposes with each other, and they are aimed at achieving goals that many Americans no longer consider a priority. Production subsidy programs, for example, create surpluses that require costly export subsidy programs to dispose of them. To stem production of surplus crops, millions of acres are laid idle at government cost—and production of other products that are in ever-greater demand overseas is stymied. Acreage bases concentrate the application of fertilizers, pesticides, and other inputs on fewer acres, increasing risks for the environment. All the while, research programs concentrate on generating more crop output, and little heed is paid to solving newer problems relating to trade and the environment.[1]

A new approach is needed for the agricultural sector—one that aims at bringing about greater harmony among agricultural production and new budget realities, the environment, and international markets. This is not to say that traditional goals should be abandoned completely. As its economy grows, the United States continues to require abundant supplies of safe and affordable food and fiber. But the tenor and realities of the times have changed, and government programs must change with them. Many citizens now view food safety, for instance, as a major concern, making the impact of farm programs on chemical use in agriculture as important as their impact on farm income and farm exports. Citizens are also demanding greater environmental protection, which puts more pressure on management programs. Income levels of farm households are now on a par with nonfarm households, raising questions about programs that transfer government payments to the farm sector. And with regard to trade, consumer demand abroad now favors a mix of U.S. agricultural exports that includes more horticultural and highly processed food. Consequently, the composition of agricultural goods has become as important to reducing the nation's trade deficit as the expansion of export tonnage but is not reflected in

[1] Research to increase output of price-supported crops continued long after surpluses accumulated at least partly because farmers were protected from losses on increased production. Research institutions were in turn protected from the normal effects that producer losses would have had on public support for such research projects. How research allocations in land grant universities would have changed in the absence of price support programs is open to varying interpretations ranging from "not much" to "a lot." This assessment did not attempt to complete an in-depth evaluation of this issue.

federal policies on export promotion. To take greater advantage of evolving opportunities for expanded trade, farm production patterns must be allowed to respond more to market forces rather than being constrained by traditional farm commodity programs. Such flexibility is consistent with new budget realities that favor reallocation, if not reduction, of funds for agricultural programs.

One alternative for moving toward more market-oriented farm programs would be to continue the trends established in the 1985 and 1990 farm bills. This approach would pose few surprises for market participants. After 60 years, commodity programs have become well known and their impacts can be anticipated. Changes in weather and variation in export demand remain the primary sources of variation in program costs and farm incomes. Rising levels of productivity also affect program costs, as output pushes ahead of markets and requires budgetary expenditures on storage and export disposal programs. Coupled with the budgetary costs for direct production subsidies, such expenditures can be sizable and difficult to estimate precisely, given the uncertainty of future default rates on government-guaranteed export loans (chapter 3).

Extending current commodity programs would ensure an abundant food supply for the nation and modest increases in food prices. Budgetary costs for price and income support programs would be expected to average in the $9 billion to $11 billion range.[2] (Expenditures averaged $11.3 billion for fiscal years 1991-95.) The value of farm exports would continue to grow, with steady gains coming from increased sales of value-added food exports and occasional upswings in commodity exports. Bulk commodity exports would respond to variations in weather in other countries and changes in internal policies. Aggregate farm income would remain fairly constant, especially in real terms, with sudden boosts in the occasional year of drought or other natural disasters overseas. Per capita farm income would increase as farm numbers decline.

There are, however, numerous other approaches to farm legislation beyond an extension of current programs, ranging from the elimination of direct payments and price support programs to the targeting of price support programs toward small and moderate-size farms or environmental enhancement. Which kinds of farm programs should be implemented, how much funding they should receive, and where they should be targeted are issues to be decided through the legislative process. OTA's goal, in the following sections, is to outline a selected set of available options to enhance policy discussions.

ISSUE 1: *Harmonize Farm Commodity Programs and International Market Trends.*

U.S. farm commodity programs have at times hindered efforts to expand agricultural trade. As discussed previously in this report, the United States implemented large acreage reduction programs to hold down production of major crops (e.g., wheat, feed grains, rice, and cotton) throughout most of the 1980s. To ensure that acreage would be reduced, the government required farmers to cut back on the amount of land they planted in return for federal payments. The programs had an unintended effect on trade: along with reducing acreage of the program crops, they also reduced acreage of soybeans—a nonprogram crop—which were in great demand in international markets. Competitor countries took advantage of those markets, expanding their acreage of soybeans to meet global demands. Similarly, the United States has continued to implement commodity programs that focus land resources very

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[2]The Congressional Budget Office (CBO) reported on Mar. 6, 1995, in a personal communication, that budget expenditures for CCC net outlays for commodity programs are expected to average $8.4 billion from FY 1995 to FY 2000. In arriving at this figure CBO excluded disaster payments, included the effects of the new Uruguay Round agreement provisions, assumed that there would be no wool and mohair payments after FY 1996, and assumed that dairy expenditures would remain low.

heavily on a few bulk commodities—even as global markets shift away from bulk commodities and toward more trade in value-added food products.[3]

The 1990 farm bill gave farmers some additional flexibility as to how they could use their program acres, but only modest changes in land use resulted. An important goal of the bill—a substantial increase in soybean acreage—was not achieved. Some expansion of value-added food exports occurred, but not at rates equal to the expansion in global markets (chapter 3). If the United States is to fully use its natural advantages in agricultural production in the future, additional changes in farm legislation are required. Three options are examined below.

OPTION A:* *Phase out all income transfer programs for agriculture between 1995 and 2000, and allow land use and exports to respond to signals from national and international markets.

Income transfer programs (also known as target price or deficiency payment programs) provide farmers with direct payments from the federal treasury. Their purpose is to stabilize farm income by protecting farmers against fluctuations in commodity prices. When the market price of a commodity rises above its target price, a producer receives no payments. When market prices are below target prices, the government makes payments to producers to compensate for the difference between market prices and target prices. In other words, income risks are shifted from farmers to taxpayers at large.[4]

The impact of eliminating target price payments over a five-year period would be concentrated on farmers producing target price crops. As the economic returns for these crops declined, some farmers in higher-cost regions would discontinue production, shifting land and capital resources to other crops and to livestock production. Other farmers in low-cost production areas might expand production as their counterparts in high-cost areas stopped planting these crops. Commercial farmers would make the adjustments relatively quickly, where adjustments were economically beneficial. Part-time farmers might be less responsive, since most depend less on income from farming and are perhaps less attuned to commodity market changes.[5]

For the sector as a whole, the impact on farm income from eliminating direct government payments would be modest. As illustrated in chapter 2 (figure 2-5), the decline in direct government payments between 1987 and 1993 was more than offset by increases in cash receipts. With farm numbers declining between 1987 and 1993, average per-farm income from farming activities in-

[3]Producer payments under commodity programs have distorted cropland use in agricultural production, although estimates of the amount are lacking. What is clear is that program payments have tied too many acres of cropland to surplus crops such as wheat, rice, cotton, and feed grains, and resulted in acreage diversion programs which, in turn, left fewer acres available for crops, such as soybeans, that have experienced growing global markets for products. The cost of this distortion may be significant. Had soybean acreage, for example, continued to expand in the 1980s to meet growing global markets, instead of declining, the need for acreage diversion programs would have been diminished or even eliminated. Of course, other countries' policies relating to export subsidies also played a role in these trends and international trade negotiations were used to reverse these directions. However, trade negotiations turned out to be a rather weak tool for maintaining U.S. global market share for soybean products.

[4]Established in the 1973 farm bill and extended in the farm bills of 1977, 1981, 1985, and 1990, target price payments are calculated as the difference between the target price and the market price (or the loan rate, whichever is higher) of a commodity, multiplied by a farmer's eligible production, where eligible production is based on a farmer's historical acreage base and yield history. After the payment is calculated, a treasury check is issued to the farmer for the amount of the payment. In 1994, for example, the target price for wheat was $4 a bushel and the projected target price payment was 85 cents a bushel. A farmer with 20,000 bushels of eligible wheat would have received a $17,000 payment from the government.

[5]The 1995 *Economic Report of the President* notes that about one-third of all farmers receive payments. "Moreover, two-thirds of program payments go to the largest 18 percent of farms—even though the average income of these recipients is triple that of the average U.S. household (p. 142)."

creased over this period. When rising income from off-farm sources is included with farm income, both U.S. Department of Agriculture (USDA) and Census Bureau data indicate that farm households earned incomes, on average, that were equal to those earned by the rest of the nation's households (chapter 2). This trend would likely continue with a phaseout of target price payments. Cash receipts, which rose by an average of $5.3 billion annually between 1987 and 1993, would rise as exports, industrial uses, and other uses of farm commodities increased. The increases would accrue to farms producing food items in growing export demand or commodities for expanding industrial uses.

Under a phaseout of direct payments, incomes on larger farms would likely decline the most. The current distribution of payments favors larger farms, although target price crops are a smaller part of the overall output for many of these farms than for smaller farms. Losses for the larger farms would be mitigated by income from other sources, such as nontarget price crops and livestock products.

As noted above, some indication of the aggregate impact on farm income can be ascertained from the results of the 1990 farm bill. That legislation lowered the percentage of program acres on which payments were made from 100 to 85 percent. Aggregate farm income showed no noticeable reduction as a result of the change. Although the elimination of farm program payments would not be achieved as painlessly, especially for farmers producing target price crops, the impact on aggregate farm income would be moderate if phased in over a five-year period. The impact would be relatively mild for farmers who are flexible and able to shift some of their resources to producing other crops.

Land values would decline with the elimination of programs benefits, especially in the initial period of uncertainty following the establishment of such a policy. The real price of land, as opposed to the nominal price, might decline for a number of years until production patterns fully adjusted to market forces. The decline and duration would depend partly on how aggressively the United States took advantage of opportunities for exporting items that are in growing demand (such as fruits and vegetable, red meats, and oilseed products) and partly on whether commodity support programs were withdrawn suddenly or phased out gradually.

Export composition would be affected by eliminating production payments. Some reduction in export subsidy costs could be expected as the incentives for producing surplus crops declined. The mix of crops planted and harvested would change: fewer acres of program crops would be planted in regions with fewer natural advantages and more acres in regions with greater natural advantages. For example, wheat production would tend to be concentrated more in the Great Plains and corn production in the Corn Belt, as land-idling programs became less attractive to growers in these regions. Production would be discouraged in other regions where acreage has expanded to take advantage of programs benefits.

As acreage was concentrated in areas of natural advantage, the average costs of production would decline, making the United States more competitive in global markets and improving economic conditions in rural areas. More acreage in production would mean more purchases of inputs and other products, which in turn would strengthen tax bases and other institutional systems. The condition of streams and groundwater might, however, worsen in areas where more crops were grown, if erosion and applications of chemical fertilizers and pesticides increased.

The budgetary implications of eliminating direct payments for farmers under commodity programs are significant. In 1993, direct payments amounted to $8.6 billion of the $16.0 billion spent on price and income support programs; in 1994, $4.6 billion was spent on direct payments, out of a total of $11.8 billion. Direct payments are expected to total $5.0 billion in 1995, with total costs for farm programs set at $9.8 billion. (Direct payments are payments made to farmers under target price programs, marketing loan programs, and other minor crop or livestock programs. Additional costs for storage, interest, and other expenses for operating storage and export disposal programs are not included in direct payments, but are included in the total amounts spent on price and income support programs. These other costs would decline if the incentive to produce surpluses were eliminated.)

There would be little impact on food prices from a withdrawal of direct government payments. Less production of target price crops in less advantageous areas would be offset by more production in areas of natural advantage. Over time, shifts in production patterns would lead to fewer surpluses, fewer export subsidies, and smaller expenditures for disposing of surplus commodities. If export programs continued to be operated aggressively with smaller supplies, food prices would increase more, as they are linked to export subsidy programs—a point driven home after the severe drought of 1988. With export subsidy programs operated aggressively in 1989 and 1990, consumer food prices increased 5.8 percent each year, well above normal increases.

The impact on farm numbers, farm size, and farm structure is difficult to forecast. Most smaller farms depend primarily on income earned off the farm, and the situation would not change if direct government payments were eliminated. The total number of farms, however, would likely continue to decline.

OPTION B: ***Phase out both commodity loan and storage programs and direct income transfer programs between 1995 and 2000.***

Other major income stabilization programs extended to agriculture are nonrecourse loan and storage programs. These programs are designed to ensure the orderly marketing of farm commodities by reducing the amount of commodities coming to market at harvest time and increasing marketings at other times during the year. The government offers farmers loans based on the quantity of their commodities and equal in value to a specified support price multiplied by the quantity of commodities. The stored commodities act as collateral to secure the loans, and when the loan is due, the grower may pay off the loan and reclaim the commodities or turn over the commodities to the government as full payment of the loan, regardless of the price and value of the commodities. If the commodities are valued at less than the loan, the government absorbs the loss (hence the term "nonrecourse loans"). Another variant, the marketing loan program, allows farmers to repay loans at world prices, which generally are lower than U.S. prices. Losses on loan and storage programs will total $4.0 billion for fiscal years 1991 through 1995.

The elimination of loan and storage programs would increase instability in farm commodity markets, although the degree of instability is difficult to estimate. Certainly, some instability would be offset by the many new marketing arrangements that have evolved in recent years, such as futures markets, contract farming, vertical integration, and forward sales through elevators and other private firms (chapter 2). All such arrangements have become stabilizing mechanisms that even out sales throughout the marketing year. Nonetheless, the uncertainty accompanying the end of government-sponsored stabilization programs would have marked effects. Farm markets have not been free of government involvement for more than 60 years, and there are few, if any, farmers or other market participants who can even recall farm commodity markets in which the forces of supply and demand alone established prices and determined sales. Global demand has become more important, increasing the importance of factors such as weather on other continents (and, especially, in the southern hemisphere). At the same time, other factors such as improved global communications have diminished the impacts of weather, and of new seed varieties, by keeping all market participants better informed. None of these factors pertained when markets were last free of direct government influence.

The greatest impact of eliminating commodity loan and storage programs over a five-year period would be the adjustments required of individual growers and other market participants. No longer would farmers who place commodities in storage and file for a commodity loan with a U.S. Department of Agriculture (USDA) agency be able to use such a simple marketing plan. Marketing decisions would be more complex, involving greater awareness of trends and events occurring at home and overseas. In the initial period, it is quite likely that market prices would fluctuate more, and farmers would find it necessary to develop new marketing techniques. With a few years of experience, the variability in markets and market prices would be expected to diminish as private stabilizers (e.g., vertical integration, future sales arrangements, contract farming, hedging on futures markets, and so forth) replaced government mechanisms.

The economic impact of this option is difficult to estimate with accuracy, and the behavior of the private storage trade is difficult to judge. Available studies tend to examine relatively small changes in loan rates rather than their elimination. Such estimates probably are not very good guides to the events and trends that would transpire with the end of stabilization programs. A five-year phaseout of these programs would give all sides time to analyze conditions and take steps to protect their own interests. For some, that might mean building storage facilities. For others, it might mean developing new marketing relationships with local elevators or other agribusiness firms. For all farmers, it would require more attention to market details. Planning for marketing of crops would become as important as planning for planting and harvesting if loan and storage programs were eliminated.

The largest economic impact of this option would fall on farmers without the capacity to carry stocks of commodities beyond harvest time. These farmers would receive lower prices and lose income if they were forced to sell at harvest time. Any impact on land values would follow from the impact on crop prices. If relatively few farmers increased their marketings at harvest, the impact would be small. In general, though, land buyers would reduce risk by offering less for land, which could result in lower land prices until growers gained experience with open markets. Depending on the degree of added price variability, consumers might see some additional fluctuations in food prices.

Budgetary costs for loan and storage programs would be reduced, saving up to $4 billion between 1995 and 2000. The composition of agricultural exports would change as commodity programs gave less support to production of price-supported crops; fewer surplus commodities would mean lower expenditures on export subsidies. The impact on rural communities would vary. There would be losses in areas where commodity programs now induce farmers to maintain acreage of crops against the forces of natural advantage.

OPTION C: ***Target commodity loan and storage programs to small and moderate-size farms.***

The major impact of eliminating loan and storage programs would fall on farmers who could not carry their commodities beyond harvest time in years of unusually low prices. These farmers would be forced to sell their commodities at the lowest part of the annual price cycle, to earn funds to pay for harvesting and other operational costs. They would thus accept losses on crops that, if held for a few months, might be sold for higher prices. Scenarios such as this originally led to the establishment of USDA's Commodity Credit Corp. (CCC), which funds current loan and storage programs.

An alternative to eliminating these programs would be to limit access to them, by placing a cap on the amount of commodities that could be placed under loan by any one farmer. The cap could be set at various levels, although a limit on the average amount of wheat, corn, cotton, rice, or soybeans grown on farms producing those commodities would seem reasonable. If the average wheat farm, for example, harvests 300 acres of wheat, with an average yield of 40 bushels per acre or 12,000 bushels of wheat, the loan program could be limited to placing this much wheat under loan at the 1994 loan rate of $2.58 per bushel. If the average corn farm harvests 200 acres of corn, yielding 125 bushels per acre or 25,000 bushels of corn at the 1994 loan rate of $1.89 per bushel, the loan program could be limited to placing this quantity of corn under loan annually. Other crops could have quantity limitations that reflect average farm size.

Placing limits on eligibility for price support loans would break with tradition. Although limits have been imposed on direct payments to farmers from the government, loan and storage programs have remained open-ended. As farm size increased and productivity rose, the quantities that any one producer could place under loan gradually increased. However, increased eligibility did not result in an automatic increase in budget costs. Stocks accumulated in one period have been sold at a gain in a later period. For example, following the drought of 1988, CCC price support operations returned to the government $926 million over costs in FY 1989 and $399 million over costs in FY 1990. These gains were more than offset in FY 1993, however, when losses on price support operations amounted to $2.1 billion, and in FY 1994, when losses were $621 million.

Under this option, small and moderate-size farms would continue to be eligible for full loan coverage, while larger farms would be forced to turn to other price stabilization methods and other sources of credit. One result might be that farms would tend to diversify their cropping patterns, so that a maximum amount of several crops could be placed under loan. For example, a large wheat farm might plant part of its holdings in another crop, so that it would be eligible for loan coverage. In such circumstances, it might be necessary to place an upper limit on the total amount of loans that the CCC would give to any one farmer. Other federal entities impose such limits: the Small Business Administration, as an example, sets a loan limit of $500,000 for any one business. A similar limit for any one farm for all commodity loans would not be unreasonable.

The economic impact of targeting loan program benefits would be modest. Small and moderate-size farms would retain a substantial degree of stabilization. Larger farms would turn even more to forward contracting, hedging, and other private risk-reduction alternatives. Land values would be relatively unaffected. Budget outlays on price support programs would be less than the $4 billion spent between fiscal years 1991 and 1995. As long as loan rates were held below market prices, farmers would not turn over large amount of commodities to the CCC. Exports of commodities would be modestly encouraged. Large farms with large quantities of ineligible commodities might tend to sell more commodities at harvest time, which could lower annual average prices and increase international competitiveness. Alternatively, CCC loan programs might be less important to these farms and limits on loan size would therefore have little effect. The impact on farm structure would be modest, although risk would increase for larger farms, which could discourage concentration of acreage in fewer hands. If the number of farms stabilized to a greater degree, rural communities would benefit.

ISSUE 2: Align export promotion programs and global agricultural markets.

As noted throughout this report, the composition of world food trade has changed, and international markets now favor higher valued food items. The share accounted for by consumer-oriented food products rose 17 percentage points between 1980 and 1993, and the share accounted for by intermediate food products increased 3 percentage points. In contrast, the share accounted for by bulk commodities fell by 20 percentage points, from 49 to 29 percent of total global trade. Over the same period, U.S. export shares also changed: consumer-oriented food products rose 23 points and intermediate food products rose 3 points. The share accounted for by bulk commodities declined 26 points, from 70 to 44 percent. In January 1995, USDA reported that "[h]igh-value product exports reached $25.9 billion, or 60 percent of total export value in fiscal year 1994, up from a 56-percent share the previous year." The shift also had a regional component. Asia surpassed Europe as the main market for U.S. agricultural exports in 1978 and slowly expanded its share of U.S. exports in the intervening years.

Such a large change in the composition of world food trade in the course of only a decade has placed the United States, with its heavy emphasis on bulk commodities, at a disadvantage. Large export subsidies were required to dispose of the surplus commodities that were being produced under the incentive of domestic farm programs (chapter 3). As commodity exports shrank in the early 1980s, farm income declined and rural land values dropped sharply, creating crisis conditions across the grainbelt and raising questions about the effectiveness of export promotion programs. A subsequent assessment of the programs concluded that "USDA's allocation of market development funds has sometimes taken place without sufficient regard to maximizing the effectiveness of these expenditures with respect to either expanding exports or benefiting agricultural producers." (See chapter 2.)

While the evidence gathered in this study suggests changes would be useful, continuing market development and export promotion programs with their current emphasis on bulk commodities is the course of action that holds the least uncertainty for the nation. However, it poses the weakest prospect for export growth in the food sector. Commodity exports may boom in an occasional year but the longer term trend is toward expanded global trade in value-added food products (figure 2-7). Extending the current export expansion strategy would represent the least controversial approach from the standpoint of commodity organizations and other export interests. Budgetwise, market development and export promotion programs would require about $250 million dollars annually, or approximately $1.25 billion from 1995 to 2000.

This study includes three other options for ensuring that promotion programs provide maximum benefit in terms of export earnings. A prerequisite for all of the options is more and better marketing research. Less than 5 percent of all public funds for agricultural research is allocated to domestic and international market research, and little, if any, of that amount is directed toward international markets. The dramatic shift of world trade away from bulk commodities and toward value-added items went unnoticed for nearly a decade due, in part, to a lack of research on international markets. For the United States to become proficient in marketing food to international markets, it must become more knowledgeable about countries' internal conditions, about their food tastes and taboos, and about the cultural habits that shape food consumption. Then it must shape marketing programs to match other countries' needs and desires. Such work represents a major challenge for the research community, as well as the business community, in the future.

OPTION A: ***Reorient market development and export promotion programs toward products that global markets demand.***

Improving the effectiveness of export expansion programs requires a shift in emphasis and budgetary expenditures. Currently, export promotion funds are used to dispose of surpluses produced in response to commodity program incentives. If the full cost of disposing of these surpluses were totaled (including expenditures for production subsidies, market development programs, export credit costs, and export subsidies) for exporting the last several million tons of each subsidized crop, the result would likely be net costs, not net benefits. To ensure that there are net benefits to exporting agricultural products, the United States needs policies that match those products more closely with demand in evolving markets. This new approach would require changing both the commodity programs that influence the structure of farm production and the manner in which export promotion programs are operated.

The production system can be improved by allowing market prices to have a greater influence on production levels. Target prices that are frozen over a period of years are not appropriate guides for determining the composition of farm output from year to year. Such prices have nothing to do with supply and demand, and therefore may guide production along paths that have no market relevance. More appropriate guidance can be provided by international market signals, but they must be acknowledged and understood by more farmers and/or exporters. To that end, it is important to broaden the base of current knowledge about foreign markets, and to expand the pool of knowledgeable persons and firms involved in exporting. More active participation—not only by bulk commodity exporters, but also by livestock and specialty crop exporters, exporters of semi-processed-processed commodities, and exporters of highly processed food products—is essential.

One way to achieve this aim would be to revise the program evaluation process, adopting a zero-based budgeting approach for export promotion programs. Exporters would have an opportunity to submit proposals for funding projected activities over a five-year period. Proposals accepted would be funded for those five years, and funding would be phased out over a second five-year period. The primary goal would be to make export promotion programs more like pilot programs than permanent entitlements. A secondary goal would be to make federal funding available to a broader range of agricultural interests, with the prospect of maximizing export gains for the nation and for the agricultural sector. It is worth noting here that the nation has invested billions of dollars in developing a highly efficient agricultural sector and retains an interest in maximizing the role agriculture can play in reducing the nation's trade deficit. With this in mind, it seems reasonable that a full evaluation of market development and export expansion programs should be carried out to determine their current effectiveness.

If this option were adopted, a private-public cooperative arrangement would be established along the lines of the traditional market development programs, but with a broader participation base. The goal would be to take advantage of all sources of information, both public and private, to discover new market opportunities that may accrue as incomes rise in the newly industrialized countries, as populations increase in developing countries, and as changes in government regulations take place in the hundred-plus countries covered by the General Agreement on Tariffs and Trade (now the World Trade Organization or WTO).

The budgetary gains that would accrue from pursuing this option are modest. Funding for traditional export promotion programs currently totals about $250 million annually. Export subsidies under the Export Enhancement Program cost around $1 billion annually (even though the cost will decrease, as stipulated in the Uruguay Round Agreements, or URA). Expenditures for traditional market development programs total about $37 million. The relatively new Market Promotion Program has operated with a $200 million budget. Revising these programs as OTA suggests would not produce major budget savings. Instead, the major benefits would come in the form of improved program efficacy and greater opportunities for all U.S. agricultural exporters. Overseas markets are currently expanding to include a full range of food items, from bulk commodities to the thousands of food items now available in American supermarkets. A new approach would offer U.S. exporters the chance to compete more effectively in those markets.

This proposed change in approach would require a substantial change in philosophy. Increased exports would have to be seen as a means of balancing trade accounts, rather than as tools to improve specific sectors of the economy. Private business would be encouraged to open up new markets to increase export earnings for the nation, rather than boosting the earnings of a commodity group or the corporate earnings of an export company. Continuing trade deficits and the transfer of national wealth that it entails should be adequate incentive for the nation to revisit not only agricultural export promotion programs, but also the basic philosophy that underlies all U.S. export expansion policies.

OPTION B: ***Eliminate government-funded export promotion programs and turn over market development activities to private companies.***

Market development programs for agricultural commodities began during an era of commodity surpluses that followed World War II. Production had expanded to meet war needs and the end of hostilities brought a drop in global shipments, as Europe and Asia slowly resumed producing their own food. The decline had a heavy impact on U.S. farmers, who had geared up production to help the wartime efforts of the nation. As commodity stockpiles grew, every possible source of demand was examined, with the goal of getting rid of some amount of American grain or cotton. Private organizations representing wheat growers, cotton farmers, and producers of other commodities were encouraged to set up overseas market development programs. Their efforts focused on introducing American farm products to buyers in other countries. Over time, their activities broadened to include the establishment of feed mills, flour mills, bakeries, and other operations that would use bulk commodities from the United States.

Times have changed. The small organizations spawned by government-sponsored market development programs have become major organizations, using check-off funds from producers to finance activities. Federal funds still flow to these organizations to support activities from an earlier era. Most representatives of these organizations would probably argue that any reduction in federal funds would make them terminate their overseas market development activities. Although an immediate reaction might be that any cutback should not be condoned, further examination might conclude that there are few buyers around the globe who do not already know that the United States is a major supplier of bulk commodities. Furthermore, sales of bulk commodities are largely, if not totally, independent of traditional market development activities. Sales are arranged and concluded by large multinational corporations that also provide trade servicing activities if problems arise.

As the nation faces tightening budgets, the traditional market development programs of USDA could be reexamined, with the intent of phasing out government support from 1995 to 2000. If representatives of commodity organizations were still required to be stationed in overseas posts, federal support could be forthcoming in different forms. (As an example, check-off funds for paying costs of market development operations by farmers could be made tax deductible.) But if traditional market development programs were phased out, it is likely that many traditional market development activities would cease. By the same token, it is doubtful that bulk commodity exports would be affected very much. The most important impact would be the loss of mutual support that now exists between commodity organizations and the foreign arm of USDA. The current working relationships are excellent and a good example of how government and private nonprofit organizations can work together. Nevertheless, good working relationships do not substitute for serving the broader public interest.

This option calls special attention to the need for continuing trade negotiations to gain access to other country markets, and for discouraging the use of export subsidies globally. No single country can afford to eliminate market expansion programs, although countries can reassess which commodities or products will gain the most from promotion efforts.

OPTION C: ***Encourage the adoption of state-of-the-art computerized information systems to improve the process of transmitting overseas trade prospects to U.S. food exporters.***

Global trade, like all other business activities, has increased its tempo in recent decades. There are more suppliers of any given item, and there are more buyers in more countries. Exporters must compete with suppliers from other countries to satisfy foreign buyers, who have many options available for filling their needs. In these circumstances, the time that elapses between the discovery of a trading opportunity and the development of an offer to sell must be minimized. Many large companies save time by locating personnel overseas, but many smaller companies do not have the resources necessary for covering the large number of countries now engaged in agricultural trade.

One legitimate function of government, given the need to reduce the nation's trade deficit, is to assist smaller companies and firms in discovering overseas trade opportunities. Such a program already exists within USDA: Foreign Agricultural Service officers stationed in approximately 70 countries send back trade leads for U.S. businesses. As communication technologies continue to improve, the system should be updated to ensure that U.S. suppliers are provided with information about trade opportunities in the most timely fashion possible.

As an initial step toward implementing this option, congressional hearings could examine how the system currently operates, evaluate how well trade leads are being transmitted from foreign sources to U.S. exporters, and consider ways of using the information highway to improve the effectiveness of the program. The adverse consequences of updating the system would, of course, be the costs of purchasing new communications equipment and training personnel to operate it. Such training is crucial for persons who, as part of their jobs, must adjust to the constant flow of new technologies out of research laboratories.

ISSUE 3: ***Develop a new approach for stabilizing grain supplies during years of drought or other natural disasters.***

Less U.S. government involvement in setting crop production and storage levels would mean less protection against unanticipated shortfalls in crop production, either in the United States or in other countries. Such protection has been an inadvertent result of the loan and storage programs used to support domestic commodity prices. As noted in the previous section, storage programs were originally intended to provide farmers with an alternative to selling all their crops at harvest time, when prices are low. In practice, however, storage programs became a market of last resort for the surpluses that were produced over much of the period from 1933 through 1993. The result was large carryover stocks in many years, which added to government costs but also ensured that the nation would have an adequate food supply, even when drought or other weather-related disasters struck.

U.S. grain production currently exceeds domestic needs by such large margins that even such calamities as the drought of 1988 and the flood of 1993 were barely felt by the nation's consumers. The risk of supply shortages does, however, loom over consumers in other countries that import a large proportion of their total food supplies. While American consumers might face higher food prices during a global food shortage, foreign consumers—especially low-income consumers in developing countries—could face starvation. In effect, then, the insurance benefits of U.S. carryover stocks now go in part to foreign countries, while the costs for carrying those stocks are borne at home. Like other agricultural policies established decades ago, policies regarding stockpiles need to be evaluated in the new marketing situation that now faces agriculture.

Continuing agricultural storage programs is still feasible, unless budgetary restrictions become too severe. Their annual cost in recent years has approximated $800 million, which includes costs for purchase, storage, transportation, and disposal of stockpiles. Storage programs could be maintained with or without other facets of commodity programs, although the amount of stockpiles could become burdensome without production controls. Other options for managing stockpiles are developed below.

OPTION A: ***Establish an international grain reserve with special drawing rights, limited to nations that contribute to the maintenance of stockpiles.***

One option for lowering the risk of future food shortages is to shift from domestic food reserves to international food reserves, a process that has already partly occurred. In 1972, the United States carried 34 percent of global grain stocks; by 1994, the U.S. share was 25 percent, on a par with its 23-percent share of world grain production. The memory of food shortages during the early 1970s and other influences have led to larger stockpiles in other countries. But there remains a question of whether these stocks would be shared in the event that other countries suffered intense food shortages.

The major dilemma posed by maintaining an international grain stockpile is how to share the burden of costs and benefits. One option is for the United States to undertake international negotiations under the auspices of the United Nations, with the goal of establishing an international grain reserve. Countries could be allotted drawing rights in proportion to their contributions to establishing and maintaining the stockpile. Alternatively, an international institution similar to the International Monetary Fund (IMF) could be established to maintain stability in global food supplies. Some form of SDRs (the special drawing rights used by the IMF) could be used for grain rather than for currency. A third alternative would be to turn the CCC into a quasi-government corporation similar to the Farm Credit Administration and sell shares to interested nations, who would then have drawing rights on CCC stocks during global shortages. A fourth alternative would be for grain-exporting countries to band together and jointly carry a minimum level of grain reserves to be sold only during shortages.

Whichever option might be considered, the process of establishing an international grain stockpile would involve determining the proper level of stocks to cover expected variations in global grain production. Some indication can be derived from past experience. For example, a 1972 decline in world grain production of 30 million tons led to very serious world food shortages and a record increase in domestic food prices. In 1993, world grain production dropped 80 million tons, but had little effect on world food supplies. Large carryover stocks in other countries were, in part the reason that 1993's low production levels did not create havoc in world food markets.

Growth in world population (and hence vulnerability to grain shortages) will take place mostly outside the United States. The impact of future grain shortages due to bad weather will generally fall on other countries that have high population-land ratios. Initiating international stockpile discussions is one way of drawing attention to the likely impacts of future grain shortfalls. The alternative is to allow weather-induced shortages to focus attention on the issue.[6]

OPTION B: ***Phase out all government-initiated storage programs and allow market expectations to set the level of carryover stocks.***

The original establishment of grain stockpiles was inadvertent, the outgrowth of price-support programs that were established not to build stockpiles but to support farm prices and incomes. In the intervening decades, stockpiles of grain have become an end unto themselves, with grain growers receiving storage payments and, occasionally, windfall profits when world shortfalls cause prices to escalate sharply. The return of stockpiles to private hands would change the economic landscape in which commodity prices are determined, although the prices themselves might not change. In contrast to the current situation, in which commodity price increases are dampened by the existence of government-held stockpiles that may be released, a shift to privately held stockpiles would allow private holders of stocks to determine the path of commodity prices.

The dynamics of food price inflation would obviously change if this option were adopted. In the past, there has been pressure on the government to release its stocks of grain during shortages and thereby moderate food price inflation. Such pressure was balanced against interest in allowing

[6] Other analysts have suggested that the U.S. increase its food grain reserves only, e.g., raise the wheat reserve from 4 to 10 million tons as a device to protect food supplies. Such a step would provide some protection for low income countries which consume food grains as food but would give little protection to the United States, which tends to use feed grains for animal production. During the last major food crises in 1972/73, choices had to be made between allowing grain to be exported to prevent starvation or retained for animal production at home. The balance resulted in domestic food prices rising 20 percent between December 1972 and December 1973.

commodity prices to increase, so that growers could earn higher incomes. With stocks in private hands, food price inflation would no longer be the major criterion for determining when stocks are to be released. Private holders would place more emphasis on the economic gains to be achieved by holding stocks off the market until prices have risen. The limiting factor would become the availability of other countries' grain stocks, which could be shipped to the United States if domestic prices rose high enough to pay transportation and handling costs. In this context, it is worth noting that the terms of the Uruguay Round Agreements provide increased access to the U.S. grain market for foreign suppliers. More access will limit price hikes during periods of grain shortfalls and encourage release of stocks held by private firms. Essentially, the lowering of trade barriers increases the availability of supplies for all nations, and price fluctuations will be related to transportation costs as well as to domestic supply conditions.

Although the outcomes with and without government stockpiles might differ during grain shortages, the results during more normal years would generally be similar. Private stockpiling interests would evaluate supply-demand conditions and make judgments about the profitability of holding different levels of stockpiles. Sizable stocks would be held by exporting interests to ensure their ability to meet export contracts. Speculators would hold some stocks in anticipation of weather-related shortfalls in production. The level of speculative stocks would vary, with larger stocks held in the aftermath of a severe drought and lower stocks held after a series of favorable weather years.

As the stocks of other countries have grown, and as trade agreements have increased access to supplies from other countries, it appears more and more possible to extract the U.S. government from its current role in stockpiling programs. In closing, however, it should be indicated that doing so could have significant ramifications for U.S. foreign policy. In the event of a global shortfall, for instance, the United States might be faced with having to discourage exports to maintain price stability—which would raise concerns in foreign countries and in U.S. foreign policy circles. It is essential to balance this potential problem against the gains that would accrue from the elimination of government-held stockpiles to determine the best outcome for the nation.

POLICY OPTIONS FOR AGRICULTURE AND THE ENVIRONMENT

The U.S. public has developed a broader appreciation of agriculture's relationship to the environment since the 1970s. Agricultural production exerts detectable and, in many regions of the country, significant effects on the quality of water, wildlife, and soil resources (chapter 4). Although short-run trade projections do not indicate a large expansion in those effects, long-term production and world population growth will likely intensify pressure. At present, there are four major constraints inhibiting attempts to address agriculture's broader environmental agenda:

- environmental goals for agriculture remain unclear;
- inadequate science and monitoring hamper agroenvironmental priority setting and program design;
- many agroenvironmental programs do not adequately recognize the roles of private incentives and disincentives in program execution; and
- research and development to provide complementary technologies that link production and environmental goals have not been given priority, thus reducing options and flexibility.

These four constraints are all interrelated. Obviously, agriculture's environmental goals must be defined before programs to achieve those goals can be designed, and improved agroenvironmental science is crucial to identifying priority targets and implementing programs effectively. With clear program directions, improved science, and better functioning markets, however, public and private technology research and development can be mobilized to alleviate agroenvironmental problems more efficiently.

Establishing Environmental Goals for Agriculture

Despite six successive decades of federal involvement in conservation programs, the U.S. agricultural sector remains without comprehensive and consistent goals concerning water quality, soil quality, and wildlife resources (chapter 4). One such goal might be to eliminate agricultural water pollution that violates minimum drinking water standards by 2010. Related objectives could specify the nature of pollution reductions by given dates; for example, the control of fecal coliform bacteria and other pollutants from confined animal feeding operations by 2005.

Current environmental management efforts affecting agriculture emanate from at least 40 federal programs, begun at varying times to address specific issues (chapter 4). This plethora of programs reflects the incremental approach the federal government has taken to solving agriculture's environmental problems, which has resulted in fragmentation as well as possible confusion and conflict. A comprehensive evaluation of the many programs within USDA or in all federal agencies has not been undertaken to determine their consistency and overall efficacy.

The absence of consistent and comprehensive goals poses significant uncertainty and costs for farmers, ranchers, agribusiness, environment users, consumers, and government agencies. Pressures from long-term production and trade growth, coupled with increasing use of the rural environment, will likely exacerbate the situation. Placing U.S. agriculture on an economically and environmentally sustainable path requires comprehensive agroenvironmental goals, not only to guide current management efforts, but also to encourage public and private development and application of technologies that promote financial and environmental health.

Environmental goals for agriculture could be established in three ways. First, Congress could clarify the goals that are explicit or implicit in the 40 existing programs. This approach has not been taken for other industrial sectors perhaps because an industry-by-industry approach varies from overarching water, air, and other major legislation aimed at specific environmental resources or problems. Second, Congress could instruct an agency, such as USDA or the U.S. Environmental Protection Agency (EPA), to establish goals, drawing on input from industry, other federal agencies, state and local government, environmental interests, and other stakeholders. Again, there is little evidence to suggest such a top-down approach might be successful due to the combination of large deliberation costs and the industry not having a lead role in setting the goals.[7]

The third approach would vest responsibility for establishing goals in the private sector, with facilitation by government and input from other stakeholders. Of course, the private sector's environmental goals would be established under applicable government legislative requirements, such as the Safe Drinking Water Act's standards, to ensure the broader public interest. Preliminary evidence indicates that this private sector approach is feasible. The lndustries of the Future (IOF) program, which the U. S. Department of Energy (DOE) initiated in 1992, works with the country's seven most energy- and waste-intensive industries to establish future goals, including environmental improvement, thereby creating a future investment strategy (6). The Department's objective is to use industries' visions and goals to target its technology research and development assistance. Several sectors have established their goals or are in the process of doing so working cooperatively with the government agency. Complementing the IOF is EPA's Common Sense Initiative (CSI),

[7] In 1911, Congress charged USDA with defining long-term conservation objectives on private agricultural lands through the Soil and Water Resources Conservation Act, but the resulting National Conservation Plans (NCP) have not guided federal, state, or private activities. As evidence, the 1992 NCP did not receive congressional hearings, and the conservation objectives of the 1985 and 1990 farm legislation do not draw on the NCP goals or related discussions (13).

introduced in 1994. Through the Initiative, EPA works cooperatively with six pilot industries and all stakeholders to construct environmental plans that are to be applied industry by industry, rather than pollutant by pollutant (8). By design, a number of the Initiative's pilot industries are the same as those under the IOF program. Because the CSI has just gotten under way, it is not possible to evaluate its efficacy.

The IOF and CSI approaches capitalize on industry leadership and/or stakeholder input to create better opportunities for devising environmental programs that complement private incentives. It may be more difficult to establish private goals for agriculture, because of the large number of farm groups and other stakeholders, the many different kinds of production operations, and the expansive nature of environmental interactions. However, the private sector approach has the natural advantage of putting industry in a lead role to clarify its goals, thereby providing guidance for governmental program assistance.

ISSUE 1: ***Strengthen agroenvironmental science and monitoring.***

Agriculture's relationships to water quality, soil quality, and wildlife health have not been comprehensively monitored or documented, despite numerous regional and local studies. The major obstacles to better knowledge have been relatively meager funding for environmental issues (about 10 percent of the federal agricultural research budget has been devoted to research on such subjects, compared with about 60 percent for productivity studies[8]), and the absence of an overarching federal agroenvironmental research agenda to promote targeted and coordinated agroenvironmental programs. Existing federal research programs have been described as lacking consistent goals and mechanisms to target key national priorities. Agroenvironmental research has become a bit more of a priority recently, but the efforts have been judged insufficient and untargeted by scientific associations. The upshot is that the current information base lacks comprehensive data on environmental conditions, the relationships between agricultural and environmental systems, and related biological health issues that are precise enough to guide policymaking, program implementation, and technological innovation (chapter 4).

Incomplete monitoring and science lead to two risks: the risk of acting too late or too narrowly to address environmental quality problems, and the risk of over regulation and lost competitiveness. Redirecting research to investigate the full range of environmental issues related to production, rather than almost exclusively pursuing higher yields, could lead to greater compatibility between agricultural practices and the environment. It is true that redirecting some funds away from improving production could cause concerns about food security. However, a shift in research toward complementarity rather than competitiveness between agricultural production and environmental quality could simultaneously address productivity and environmental goals. The two options presented here offer opportunities to achieve more complementarity.

OPTION A: ***Congress could fund more federal research to strengthen knowledge of agroenvironmental systems, conditions, and implications.***

Three key agroenvironmental topics deserve more emphasis than they have been receiving: 1) the interaction of agricultural and environmental systems, 2) the geographic patterns of agroenvironmental conditions, and 3) their environmental health implications. Improved knowledge of these subjects would likely benefit the environ-

[8]It could be argued that productivity research contributes to enhanced environmental health by reducing stress on the land and water base to grow a given amount of food and fiber. However, this outcome has not been a major goal of the agricultural research programs and their fund allocations. Comprehensive evidence on the potential beneficial effects of productivity research in comparison to potential degradation is lacking.

ment as well as long-term industry competitiveness by allowing more precise program applications and minimizing unnecessary burdens.

Current agroenvironmental research institutions may neglect to examine key environmental questions needed for policy response, such as the cumulative and interactive effects of agrichemicals on biological health. The sophistication and cost-effectiveness of federal research at USDA, EPA, and the U.S. Department of the Interior could be enhanced by enacting a policy stipulating that all applied research funding decisions with agroenvironmental implications incorporate production, natural resource, and environmental factors. By implementing such a policy, government would recognize the need for a full accounting of significant environmental effects to supplement the market incentives driving productivity, thus encouraging complementary approaches. Such a policy also begins to lay the foundation for more effective program targeting and for developing innovative complementary technologies (chapter 4).

A research planning survey could examine the environmentally related data produced by all federal agencies to identify important "gaps," and reserve funds for a "gaps research portfolio." That portfolio could be guided, at least initially, by existing evaluations of agroenvironmental research, such as National Research Council (NRC) studies, and by expert panels. Innovative federal data collection groups such as the Federal Geographic Data Committee, the Consortium for International Earth Science Information Network, and EPA's Environmental Monitoring and Assessment Program could assist in such a gap analysis and portfolio design. Although data gaps and quality problems would not be eliminated by agency collaboration, these efforts could help improve overall data quality.

Additional incentives could be given to promote private-sector involvement in public research, such as granting limited patent protection or exclusive licenses for private-sector innovators. The research capabilities of agribusiness and environmental organizations could also be included in federal agency research efforts. However, private participation in agroenvironmental research may be limited by potential conflicts of interest between public and private goals, as well as the costs of collaboration. (The potential for public-private partnerships is discussed more fully in Issue 3, Option B.)

Without a clear federal commitment to improve agroenvironmental research and providing sufficient rewards to scientists, agency administrators can anticipate lost resources in endless coordination meetings. The chief potential drawback to redirecting research, however, may be agency resistance to the reallocation of existing authorization. Ultimately, bureaucratic incentives must be restructured to reward collaborative and coordinated research on priority issues. If, for technical or bureaucratic reasons, interagency coordination and collaboration prove impossible, Congress could assign full responsibility to one agency—for example, USDA or EPA. Without a strong commitment by Congress to redirecting agricultural research toward environmental topics, the criteria and standards by which departments will judge grant proposals will become bureaucratic hurdles rather than effective filters. If the research reallocation is implemented under the condition of no new funding, the shift of some production research funds to agroenvironmental research may meet institutional resistance. Therefore, development of a focused and well-documented research agenda is a prerequisite to such a research reallocation.

An initial research priority would be the establishment of a comprehensive set of minimum standards that ensure sustainable biological health. Some federal guidelines (standards) have already been established, particularly for drinking water quality (chapter 4, appendix 1), but these guidelines mostly concern human health and may not address all potential environmental problems. As a first step, more complete water quality standards can be devised. Water quality may be the best single indicator of agriculture's role in environmental conditions affecting biological health. The quality of surface and ground waters directly affect drinking water, aquatic habitat, and recreational uses such as swimming, boating, and fishing. The quality of surface water defines the viability of much terrestrial habitat and is closely related to soil quality; water is perhaps the most important factor in the transport of pollutants through waterways or through atmospheric cycles.

Developing biological health guidelines is likely to be resource-intensive, although much of the cost could be redirected from existing federal agricultural research. Coordinating and streamlining research initiatives would be achieved by redirecting rather than augmenting existing budget authorization. Budget redirection of this kind would clarify the federal goals and provide for more strategic management of existing research and program funds. Given the difficulty of the task, a periodic congressional oversight schedule would help ensure that standards were devised in a timely fashion.

OPTION B: ***Congress could direct that improved science be used to target high-priority agroenvironmental problems.***

Since the mid-1980s, federal conservation and environmental programs relating to agriculture have been increasingly focused on particular problems and geographic areas. Unfortunately, weak and incomplete agroenvironmental science hampers the potential of targeting. As noted above, increased understanding of the interlinking of agricultural and environmental systems, geographic conditions, and biological health implications would aid targeting.

Until these weaknesses are remedied, opportunities for improved targeting exist with available information. The most elaborate targeting protocol emerged from congressional instructions in the 1990 farm legislation to improve the environmental cost-effectiveness of CRP enrollments. Three steps were taken: the list of eligible lands was enlarged to include special water quality areas, a rental bid cap was established so that CRP payments could not be more than the market rate, and parcels were ranked by a calculated environmental benefit index. Analyses of the results suggests that the targeting process did improve environmental benefits per dollar of CRP expenditure. Nonetheless, further improvements are possible, including the addition of other environmental dimensions such as wildlife. Applying this kind of targeting process to other agroenvironmental programs for water and soil quality, wetlands protection and wildlife habitat holds the potential to improve cost-effectiveness.

To further improve targeting efficacy in the face of incomplete science, Congress could assemble a group of leading scientific experts to assist in identifying priority areas. Box 7-1 describes an exercise that OTA conducted to investigate the feasibility of improved national targeting using expert scientific judgment. The process proved to be low cost and resulted in certain geographical targets serving multiple subjects such as water quality, soil quality, and rangeland health and wildlife. The expert panel could be a first national step toward identifying priorities, followed by further refinement of priorities at the state or local levels, where knowledge of environmental details is greatest. Targeting within even a single watershed can improve program efficacy.

Targeting would involve costs for information collection and analysis. Public investments in research and technology can reduce those information costs. Targeting program efforts to high-priority areas may also involve higher program costs to make changes in land and water use, as evidenced by the increased rental payments for targeted CRP enrollments after 1990. However, the higher program benefits may still exceed costs. Finally, the reallocation of agroenvironmental program assistance will likely induce political resistance from those benefiting from the current distribution.

ISSUE 2: ***Strategically target agroenvironmental programs based on private incentives.***

Evaluations indicate that strategic improvements in the way agroenvironmental program approaches are employed would provide more enduring and cost-effective solutions (chapter 4). In general, they have not been targeted enough to the situations where the program complements private incentives or offsets private disincentives.

BOX 7-1: Using an Expert Panel for Environmental Targeting

OTA convened a group of leading scientists to examine 10 major environmental subjects related to agriculture: soil quality, surface water quality, groundwater quality, water conservation, wetlands, range-lands, rural landscapes, plant diversity, insect diversity, and wildlife. The principal purpose of the exercise was to determine whether it was possible to identify geographical priorities for each subject. Each panelist had a simple but challenging task: draw up a list of the 10 areas in the country that should receive targeted program attention for his or her subject The physical size of the geographic area was not restricted, but panelists were asked to be as precise (and keep their areas as small) as possible. (Large areas inherently diminish targeting efficiency, unless the environmental or conservation problem in question applies in equal measure throughout the area) A geographical information systems expert facilitated the targeting experiment.

The exercise resembled a Delphi process of soliciting expert judgment, then sharing it with other panel members and OTA staff, and then feeding it back to the panelists for possible revision. Each panelist was asked to consider environmental, economic, and social criteria in making his or her choices, but was not required to adhere to a fixed procedure. A major project goal was to extract as much expert judgment as possible from the panel members without imposing constraints on them, thus encouraging innovative approaches. (A potential disadvantage of this method is that the panelists, each using different criteria, weights, and standards, might come up with inconsistent results. However, imposing a standard protocol would either make the exercise impossible or create other unknown problems given incomplete science.) Each panelist was encouraged to consult with peers around the country to put together the best database. A majority of panelists contacted from five to 30 peers to incorporate their views. Thus, the panel's priorities reflect a broad range of professional input.

Five overall findings emerged from the exercise:

- It is possible to identify general geographic areas/regions that need special program attention--that is, it is possible to set priorities--by using existing data augmented by expert scientific judgment
- The national selection of priorities yields approximate boundaries and should be augmented by a companion state and local process to identify the most pressing problem areas and farms within the priority regions, using the best scientific expertise in those areas
- The geographical priorities for several conservation and environmental subjects overlap considerably, suggesting that the potential for program complementarily exists.
- In the process of selecting priorities, weaknesses in science and data are quickly apparent These weaknesses can help define the research and data collection agendas to aid conservation and environmental monitoring and problem remediation.
- The databases on several subjects, most notably plant and insect biodiversity, are not adequate to define even approximate geographic priority areas with confidence. However, keeping these subject areas in the priority-setting process is essential to covering the whole agroenvironmental system

OTA is continuing to refine the expert panel approach to environmental targeting, with a special focus on identifying environmentally sensitive lands of national importance.

SOURCE: Office of Technology Assessment, 1995.

Voluntary education and technical assistance programs, which can work well in certain circumstances and do not incur high net costs for agriculture, have not produced significant and wide-ranging environmental results. Subsidy-based programs could be better targeted to priority areas and to implementing cost-effective technologies. As matters stand, some regulations affecting agriculture's environmental performance could be implemented in simpler and less costly ways. Two options that complement one another could potentially redress some of the current programs' shortcomings.

OPTION A: ***Congress could put existing programs into three basic approaches.***

Key to structuring more effective federal programs is identifying the strength of private incentives to implement environmental practices (chapter 4). The multiple existing programs may be categorized into three major approaches based upon the nature of those private incentives:

- When farmers have incentives to adopt technologies that increase profit and simultaneously improve environmental conditions (the "win-win" case), voluntary education and technical assistance can accelerate and expand adoption.
- For situations in which farmers have insufficient incentive to adopt technologies that provide environmental benefits to other parties, voluntary compensatory (subsidy) programs may be necessary.
- When farmers have inadequate incentives to discontinue damaging practices that violate minimum environmental standards, regulation may be necessary.

Employing this categorization offers the potential to diagnose which program is most suitable in responding to specific targets or targets where private incentives are similar. Streamlining programs in this manner can minimize overlap and conflict. It could also help evaluate program performance more systematically. For example, all problems requiring compensation to offset farmer disincentives can be put under one category to compare their relative benefit and budget consequences as a group.

Regardless of the mix of agroenvironmental programs adopted, all measures could be implemented under the guidance of a whole natural resource management farm plan. Such a plan incorporates soil quality, water quality, and wildlife habitat into the farm's production system on an integrated basis, rather than treating them as separate components. Requiring development of the plan by the farmer with expert private and public assistance, captures the operator's intimate knowledge of the farm's natural resources. That knowledge is essential to best design management systems that achieve agriculture's environmental goals while simultaneously achieving profit and production objectives.

In structuring more effective federal programs, it is also important to delegate authority and responsibility to the governmental levels at which programs can be operated most cost-effectively. Federal leadership and oversight will be needed to achieve national environmental goals that apply uniformly across the country, such as decreasing pollutants in air or water that cross state or national borders. However, state and local governments likely have the best information in their areas on environmental benefits and incentives to reduce compliance costs in achieving national goals.

Education and Technical Assistance

As noted above, voluntary education and technical assistance programs will likely be cost effective when it comes to new technologies that offer net benefits to farmers and to the public. Such technologies as soil nutrient testing and conservation tillage, for instance, often reduce production costs as well as improve soil or water quality. Adoption of similarly beneficial technologies may be hampered, however, by lack of information, fear of the risks involved in change, insufficient financing, the need for new management skills, or conflicts with other public programs. In these cases, education and technical support, perhaps supplemented by temporary cost-sharing, may help farmers overcome their reluctance. The public environmental benefits accruing from use of the new technologies would likely be ongoing, as private interest in continuing to use the new technologies ought to be high. The costs of each educational and/or technical assistance program would depend upon the program's scope but probably would not be significant, because the infrastructure for these programs already exists.

Existing government and university education and technical assistance efforts, such as the Natural Resources Conservation Service's Conservation Technical Assistance Program and the Extension Service's outreach programs, could be focused on these opportunities. The process of constructing a whole farm natural resource plan will likely identify such education and technical assistance needs. In general, more systematic effort needs to be given to identifying the environmental problems and potential technological solutions that offer "win-win" outcomes than past program efforts. As chapter 4 revealed, there is a lack of evidence to indicate past federal education and technical assistance programs have caused significant conservation gains implying they have not been targeted predominantly to those "win-win" situations.

Compensation (Subsidies) for Environmental Services

Discussion in chapter 4 indicated that subsidy-based programs have not been well targeted. The compensatory approach should be reserved for those priority situations where the public desires performance beyond minimum environmental standards and farmers do not have natural economic incentives to achieve the desired levels. Vermont's nonpoint water pollution control program rewards farmers in this manner after they have fulfilled minimum practice requirements.[9] At the national level, the present ambiguity about environmental goals relating to agriculture means that minimum standards are determined program by program rather than for all subsidy programs as a group.

A critical first step in improving subsidy program performance is to employ the geographical targeting protocol described in Issue 1, Option B. Where federal funds are being used, the national identification of priorities is necessary to ensure national goals are served. State and local authorities can further refine the targets after the selection of national priority areas.

The next step is to identify cost-effective practices for the environmental situation. Subsidies should finance contracts or practices that provide the broadest and most enduring environmental benefits per tax dollar spent as a matter of principle.[10] For example, if the environmental problem requires long-term protection, such as the restoration of migratory wildlife habitat to allow population recovery, then securing a long-term practice avoids the administrative cost and possible environmental disruption of renegotiating short-term arrangements. The long-term arrangement may even cost more per year but still yield greater net benefits. Also, as a rule, flexibility should be given to farmers to design and implement innovative practices that are sensitive to local conditions but satisfy national environmental performance standards. Finally, in situations that provide incentives for both the federal government and the states to undertake such programs, a matching block grant program could be used.

[9]To improve state water quality, Vermont has established a two-tiered system of approved agricultural practices (AAP's) and best management practices (BMP's) that, when signed into law in 1995, will apply to all Vermont farmers (9). AAP's define categories of practices that all farmers must follow to prevent nonpoint source water pollution from agriculture; the practices relate to discharges, nutrient and pesticide storage/applications, soil cultivation, waste management, buffer zones next to streams and rivers, and structures. BMP's are anticipated to further enhance environmental benefits but adopting them is voluntary. Because BMP's confer environmental benefits in excess of their AAP responsibilities, farmers who adopt them are entitled to public payment.

[10]Programs such as this would have to be designed to avoid conflicts with Uruguay Round Agreements (URA) restrictions on agroenvironmental subsidies. The URA added three requirements to subsidy (green) payment program design: 1) payments must be part of a clearly defined government program, 2) the subsidies must have no or minimal trade-distorting effects, and 3) payments must be limited to added cost or lost income from the practice or technology shifts (chapter 5).

Regulation for Minimum Environmental Standards

If agricultural practices that do not meet minimum environmental standards cause significant public risks or costs, regulation may be the only answer. Farmers do not typically have economic incentives to change production practices that cause damages off their farm, except if they are threatened with public program sanctions or private lawsuits. Pesticides migrating to drinking waters, as well as nutrient and fecal coliform pollution from confined animal facilities, are among the agroenvironmental problems traditionally handled through regulation. Regulations are feasible only when the pollutant or desired practice can be measured and monitored for enforcement. Because agriculture has many nonpoint pollution problems diffusely spread across the land that are difficult or impossible to measure, monitor, and enforce, environmental regulation may apply to practices or quality conditions.

For regulations that apply uniformly across the nation, such as pesticide registration, or that apply to pollution flows crossing state and national borders, federal action can ensure equitable treatment over states to fulfill national responsibilities. However, in many cases, such as water quality programs, it is more technically feasible, and more efficient, to delegate implementation to state and local governments. The minimum environmental standards may have to vary by state or even within the state, according to the regional nature of environmental resources, production technologies, and public demands. In one of the first applications, Vermont has recently proposed a set of accepted agricultural practice rules applying to all farms. Where nonpoint sources dominate, monitoring regulatory compliance will likely depend on evaluating implementation of whole farm natural resource plans.

The budget cost of using regulations for minimum environmental standards is not clear. If some regulatory approaches for minimum standards replace existing subsidy programs, federal budget savings may accrue, depending on the added administrative expense of designing, monitoring, and enforcing the regulations. Costs to the private sector—for purchasing equipment to meet regulations, perhaps, or for paying noncompliance penalties—may increase. But the amount depends on the level of the standard and the regulatory mechanism used. Some alternatives to traditional regulation, which often requires farmers to choose from a list of acceptable practices, hold the potential to lower those costs. Capitalizing on the knowledge and incentives held by farmers offers ways to reduce regulatory rigidity and cost. Pollution permits may be traded among farmers to meet an overall pollution reduction goal, as air pollution rights are now traded. For example, a tradable permits program for water quality in the grasslands region of California's Central Valley could save 20 percent compared with traditional best management practices (12).

Another alternative to traditional regulation would be to exempt farmers from citizens' lawsuits and the multiple (sometimes conflicting) regulatory requirements of different agencies if they are actively implementing approved whole farm natural resource management plans for their farms. The plan would be approved by the state or federal agency responsible for implementing the regulation. The efficacy of this "regulatory exemption" approach hinges on two factors: the strength of farmers' incentives to reduce regulatory burden, avoid lawsuits, and clarify uncertain compliance status; and the costs of implementing the management plan. Public statements by farm groups suggests that the incentives may be significant for many farmers.

The costs of meeting the management plan requirements depend on the level of public environmental standards and the flexibility given the farmer in meeting the requirements. Given minimum environmental standards, the development of the detailed plan could be vested with the farmers—an approach that could promote flexible, innovative approaches. Federal and state government resources would be used primarily for education about goals and standards, as well as for monitoring and enforcement. Private-sector agroenvironmental consultants would likely respond to the planning demands by farmers and provide technical assistance. The major challenge of this approach is defining exactly what a farmer must do to be exempted from suits brought under environmental regulation and regulatory penalties. An implicit benefit of the approach is to reward farmers who have taken steps to improve the environment, rather than paying farmers to stop harming it (as past programs have).

OPTION B: ***Congress could facilitate private market approaches.***

Clearer definitions of public agroenvironmental goals, minimum quality standards for farmers, and private incentives for adopting environmentally preferred technologies or practices may facilitate market resolution of some agroenvironmental conflicts. In effect, this approach pursues private compensation for environmental services. These market approaches are not well-suited to large issues involving many diverse parties or to emergency situations. The purchase of nature preserves by nonprofit conservation organizations is a relevant example, as is the sale of recreation privileges on private farmland for hunting or other purposes. Also, clarifying the assignment of legal liability for environmental damages under common law may help resolve some local environmental disputes by private parties through the courts.

Legislative action can encourage the development of market approaches to enhance agroenvironmental management. Standardizing consumer labeling on product or process standards on agricultural products is a relevant example. Market research shows that consumers increasingly prefer purchasing food, fiber, or other products that contribute to human health and environmental quality. This trend suggests that federal involvement in standardizing labeling could be a cost-effective way of leveraging significant private sector incentives toward production and environmental complementarity within the market place. Consumer information, primarily through product labeling and reliable certification of process standards, is critical to allowing consumers to convey market preferences. Standards for organic farm products are a relevant example. Consumer demand for organic food products has shown sustained, high growth for several years.

Unlike nutritional labeling, environmental labeling remains optional, in some cases, controversial, and generally unsystematic. Process certification standards, like organic food labeling, vary from state to state and depend on the requirements of different certifying organizations. Such disorganization makes consumer choices more difficult and reduces consumer confidence in the validity of market information. The 1990 farm bill requested definitions of organic food standards, but progress has been slow.

Industry trends toward vertical coordination may tie the retail and production sectors closer together, so processors can better influence product quality and environmental side effects. Food manufacturers are increasingly negotiating contracts with producers that specify agroenvironmental practices to enhance marketing appeal (chapter 2). The federal government could play an essential role in this process by ensuring that markets can be formed and operated easily across state and country boundaries. Congressional action on these issues may also avoid the possibility of other countries restricting imports of agricultural-related products due to uncertain human and environmental health status.

ISSUE 3: ***Accelerate agroenvironmental technology research and development.***

The pursuit of complementarity between agricultural production and environmental quality objectives has not been emphasized in the United States. Although other countries also appear to have neglected such initiatives (1), the United States may be missing out on benefits of competitiveness and technology export expansion, as well as improved domestic environmental quality, by failing to stress complementary technologies for agriculture.

If production technologies can be developed that manage pollution or otherwise protect ecosystems within sustainable limits and maintain profit, they make sense from private economic, environmental health, and taxpayer perspectives. If certain technologies are widely used, they can have a significant and positive environmental impact—most notably on water and soil quality and wildlife habitat.[11] Conservation tillage, soil nutrient management, and "precision farming" are some of the most common examples cited. However, the potential of these technologies to fully capture complementary production and environmental objectives has not been assessed. The prospects for a single technological "silver bullet" are, of course, remote. More likely, a range of such technologies must be tailored to different kinds of farms and environments. Even so, it is not clear that all environmental problems can be solved in a cost-effective manner with complementary technologies. Nevertheless, the evidence indicates that they have broad potential in the United States (chapter 4).

The dominant agricultural technologies of today generally promote output efficiency, to ensure an inexpensive and abundant food supply. However, technologies oriented primarily to increasing output may have larger costs associated with them than anticipated—even in the course of normal use, some may cause excessive environmental degradation (chapter 4). Despite a well-established research and extension system, the present agricultural technology research and development agenda may not be keeping pace with changing needs of farmers, consumers, and those who use rural environment resources for recreation or other uses. Maintaining the present technology research and development strategy could ensure low-cost food supplies in the short term, and perhaps in the long term. But the toll on environmental health will likely increase. Two related options aimed at avoiding such a predicament, and at promoting complementary technology, are examined below.

OPTION A: ***Congress could make complementary technologies the centerpiece of federal agricultural research, development, and assistance.***

Congress could take a preliminary step toward promoting complementary technologies by commissioning a review and evaluation of existing agroenvironmental technology developments. Such a review would assess the prospects for improving environmental quality and agricultural productivity simultaneously in the public and private sectors. Based on such an evaluation, Congress, together with USDA, could identify the most strategic federal role in stimulating and disseminating complementary technologies.

The second step would be to redirect USDA research along the lines described in Issue 1, Option A. Congress could oversee the shift toward mutual reinforcement among efforts to promote nonchemical pest control, sustainable agriculture, water quality improvement, soil quality improvement, wildlife conservation, and productivity improvement. Potential conflicts between a complementarity focus and commodity program incentives may require legislative action.

Obstacles to refocusing USDA's research and development programs in this way may be organizational and philosophical. In its review of USDA's sustainable agriculture programs, for example, GAO found that coordinating the activities of these programs was very difficult. Coordination was a striking challenge among agencies that were under the jurisdictions of different assistant secretaries.[12] Although USDA has recently undergone a reorganization, communication prob-

[11] Foreign market opportunities for these technologies may exist as well, although the technologies require natural resource and production specific contexts.

[12] A senior USDA manager involved in directing the water quality initiative said he did not believe that water quality and sustainable agriculture goals are the same: water quality focuses on technological changes to protect groundwater, such as satellites and lasers to analyze soil; whereas sustainable agriculture focuses on biological and management changes, such as crop rotations. In contrast, a senior sustainable agriculture program official believed water quality protection and the technology development are part of the scope of sustainability (4).

lems among research, conservation, and other programs may still exist.

OPTION B: ***Congress could facilitate public private partnerships to develop complementary technologies for agriculture.***

A strategy to leverage private research and development of complementary technology with directed public funds could be both feasible and productive, especially given budget constraints. Federal/private partnerships aimed at developing complementary technologies could be better focused and significantly expanded at the national and regional levels. Such collaborations could spur a broad spectrum of private innovation dedicated to the dual objectives of making profits and promoting environmentally sound production technologies. Research and development funds could be directed specifically toward enabling producers to meet minimum environmental quality standards, for example, as outlined under Issue 2, Option A above.

In plans for its IOF partnership program, DOE characterized the goals of the new partnerships in a statement that could well apply to public/private partnerships for complementary technologies for agriculture:

> Initially spurred by a command and control mindset, industry and government have been moving rapidly toward a more sophisticated perspective that embraces pollution prevention, efficient resource use, and renewable energy. The reasons for this shift are simple: advanced, integrated process technology can simultaneously improve the efficiency of energy and resource use, improve the quality of products, and reduce waste while reducing costs and enhancing competitiveness. Such technology . . . benefits the industry, the environment, and the nation (6).

Congress could enable the partnerships to develop a range of complementary technologies, including crop rotations, diversified farming systems, biological controls for pest management, genetic engineering of crops with attributes of drought and other climatic tolerances, and computer-assisted decisionmaking systems. Such a range of technologies would be essential for an industry characterized by many different types of farming and environmental systems (chapters 2 and 4). Further, federal involvement would ensure a greater emphasis on public environmental benefits in the creation of such new technologies. In the past, applications of research into privately patented technology have generally not been constrained to provide direct public benefits, such as improved environmental quality, and so potential returns on the public investment have been lost. That would change if the options to emphasize agroenvironmental performance and complementary technologies are adopted.

Corporate partnerships will likely focus their efforts on applied research that can lead to profit-making commercial applications. Some technologies that hold significant profit potential may not require public partnership at all. ("Precision farming" may be such a case.) However, it is unlikely that the full potential to enhance public environmental performance will be captured in those cases. Some complementary technologies may not have much potential to boost corporate profits. Special public efforts may therefore be required to encourage the development of such technologies. A particularly effective model for research and development may be the federally funded Sustainable Agriculture Research and Education (SARE) program, which encourages collaborative problem solving by leveraging private innovation with public funds.

POLICY OPTIONS FOR AGRICULTURAL TRADE AND THE ENVIRONMENT

As international agricultural exports and imports grow, the environmental repercussions associated with trade and production change accordingly (chapter 5). The environmental effects of expanding domestic agricultural production to meet foreign demand during the next decade will be small overall. Some localized areas where the effects of trade are felt most, such as border zones, may be significantly affected.

The amount of environmental damage or improvement resulting from trade expansion depends principally on how effective management programs are, not on the volume of trade in question. Present programs for managing the environmental side effects of production suffer shortcomings (chapter 4). If improved through cost-effective monitoring, targeting, decentralized management, and technology development, as discussed above, the programs could cope with any significant environmental problems related to trade. They would be unlikely to have a negative influence on competitiveness or encourage agricultural producers to migrate overseas. Rather, trade will be affected primarily by the possible improper application of future environmental controls as nontariff barriers to international agricultural commerce.

The policy challenges in this arena are to ensure that management programs address the special environmental concerns related to agricultural trade--even those that transcend domestic borders and trade-related institutions. One well-publicized concern is the inadvertent importation of harmful nonindigenous species; another is how to develop trade-related institutions for coping with transboundary and global environmental problems related to expanding international agricultural commerce. A third is how to develop institutions, apart from trade organizations, to better manage global environmental resources of interest to the United States and susceptible to pressure from expanding agricultural trade. A final consideration is how to exploit opportunities for expanding environmental technology trade to assist other countries in managing agroenvironmental risks that may affect U.S. interests.

ISSUE 1: *Control invasions of harmful nonindignous species.*

Chapter 5 described how expanded international commerce opens new pathways for importation, intentional and accidental, of foreign species. Although many of the foreign species introduced (such as new plant varieties) will benefit the agricultural sector, a number will cause harm, if past events are an indicator. A partial accounting of past damages from selected previous invasions of harmful nonindigenous species (HNIS) totals about $100 billion (a figure that does not fully incorporate economic or environmental losses). Future losses from a limited number of significant cases may well exceed that figure. Both cost estimates are conservative. Many of the commercial damages are concentrated in the agricultural sector and its related natural environment.

The growing problem of nonindigenous weeds has particular relevance for agriculture. The OTA assessment reviewed in chapter 5 proposed four separate options for improving the patchwork of incomplete programs controlling their entry and spread:

> **Option:** Congress could amend and expand the Federal Noxious Weed Act to rectify several widely acknowledged problems regarding definitions, interpretations, and its relationship to the Federal Seed Act . . .
>
> **Option:** Congress could require that all entities introducing nonindigenous plant material conduct pre-release evaluations of its potential for invasiveness . . .
>
> **Option:** Congress could require that the Animal and Plant Health Inspection Service (APHIS) conduct periodic evaluations of its port and seed inspection systems to test their adequacy and provide feedback for improvements . . .
>
> **Option:** Congress could monitor and evaluate closely the weed control efforts undertaken by federal agencies as a result of the Federal Noxious Weed Act amendments in the 1990 Farm Bill (5).

As concerns about pesticide safety may reduce the range of control measures, changes in the Federal Noxious Weed Act and weed management on federal lands have particular importance for agriculture. Other aspects of the options are being addressed: APHIS, for instance, is developing performance standards for port inspection. More may be taken up in the farm bill deliberations.

Several general issues related to HNIS also relate to expanded agricultural trade and the environment. First, a comprehensive HNIS monitoring system does not exist, which means that changes in the rate or composition of invasive and detrimental species cannot be assessed. Second, there are insufficient criteria and standards to evaluate the invasive character of new species that affect agricultural production and related environmental resources. Finally, agricultural trade may be a source of HNIS that will affect the environmental health of fish, wildlife, and other natural areas. Options for addressing these problem areas include measures for improved border control and screening, control and eradication programs for natural areas (for example, parks), enhanced environmental education for prevention, better emergency responses, improved funding and accountability mechanisms, and provisions for reviewing and regulating biological control organisms.

Three types of benefits could result from low-cost improvements in targeted control, without restricting the exchange of helpful species or other trade. First, agricultural production losses from HNIS such as weeds would decline. Second, damages to protected natural areas would diminish. Finally, effective multilateral guidelines for trade involving foreign species could prevent other countries from restricting U.S. agricultural exports through misapplied health and safety regulations. Additional public resources would be needed to implement most of the options. Agricultural trade flows should not be unnecessarily restricted if control programs successfully target HNIS without negatively affecting the introduction of helpful foreign species.

ISSUE 2: ***Improve trade-related institutions for managing agricultural trade and environmental effects.***

Some of the most challenging environmental problems related to trade are transnational in nature. If one country increases its agricultural production, for example, lakes and rivers that it shares with other countries may become more polluted, and rare or endangered species that fly, swim, or walk across borders may be destroyed. Multilateral institutions geared toward addressing these problems (while ensuring that unnecessary restrictions are not imposed on trade) are now emerging. But because they are so new, there is little evidence with which to gauge their effectiveness. The two courses of action described below are intended to ensure the full and timely implementation of their agendas.

OPTION A: ***Ensure oversight of the North American Agreement on Environmental Cooperation's (NAAEC) provisions related to agriculture.***

Congress could provide timely oversight of NAAEC implementation, a landmark achievement in linking a regional environmental management agreement with a trade pact. There is little experience to draw on in anticipating the nature of progress and problems with NAAEC. It appears that some new U.S.-Mexico initiatives are under way, but significant obstacles may exist or emerge to prevent them from in achieving their full potential. The administration is responsible for collecting information on the North American Free Trade Agreement (NAFTA) and NAAEC, and could brief Congress so that it can actively treat emerging problems. The NAFTA/NAAEC implementing legislation requires periodic reporting, and this option reinforces timely reporting. A periodic oversight schedule seems prudent and a low-cost first step.

An integral part of the reporting should be assessments by the United States, Canada, and Mexico of agroenvironmental problems related to trade and progress in managing those problems. Under the agreement, the North American Commission on Environmental Cooperation must review progress and problems under the agreement, and make its assessments open to the public. Little expense should be incurred in presenting those findings to Congress on a timely, regular basis. Another part of the NAFTA/NAAEC oversight could be a review of environmental regulations that are not scientifically justifiable and serve as nontariff barriers to agricultural trade. Building a public database to accurately describe and monitor these developments would aid both governmental and private-sector efforts to minimize unnecessary obstacles while promoting legitimate environmental management.

OPTION B: ***Review the progress of the World Trade Organization (WTO) on resolving agroenvironmental issues related to trade, such as trade in genetically engineered organisms and organic farm products.***

Along with NAFTA, the Uruguay Round Agreements (URA) open the door to expanded U.S. agricultural trade with the world by lowering trade barriers and reducing export subsidies. If history is any guide, however, the food safety and environmental regulations of each member country may increasingly be used as nontariff barriers to trade. The URA established new rules on sanitary and phytosanitary (SPS) measures to protect human, animal, or plant life or health from the risks of spreading pests and diseases, and from additives or contaminants found in food, beverages, or feedstuffs. The new agreement requires that agricultural product standards be based on the best available science, sets some minimum international standards, requires risk assessment, and employs a least trade-restrictiveness test, among other provisions. A new Technical Barriers to Trade (TBT) code also establishes a standard international protocol for distinguishing legitimate uses of product standards for food labeling, packaging, composition, and other functions.

The SPS measures directly and indirectly touch on some agroenvironmental issues, such as HNIS and pesticide use and residues. However, the outcomes of SPS disputes related to environmental issues must await future WTO case rulings. There are concerns that the TBT code, in contrast to NAFTA rules, gives too much discretion to dispute panels on environmental matters (10). Apart from dispute panels, other WTO mechanisms to handle environmental matters include the Article XX (g) provision relating to conservation of natural resources, but much uncertainty also exists about their potential applicability. It may be more difficult for Congress to review the activities of the WTO's Trade and Environment Committee than to review the activities of NAAEC, because the committee's operations are not as open as those of NAAEC. However, the Office of the United States Trade Representative (USTR) is participating in the Committee's activities along with other WTO members, and should be able to keep abreast of progress and emerging problems.

The development of processes, criteria, and standards related to agricultural production technologies and products are all important agroenvironmental issues. A key concern of late has been the proper application of product-related and process standards to trade in genetically engineered plants and animals, as well as trade in organic farm products. Early scientific and policy attention to such concerns could reduce the possibility of unnecessary trade restrictions and significant environmental risks. Other process and production method (PPM) issues related to agriculture—for which there are no clear guidelines and rules—may arise. There are currently, for example, proposals to develop guidelines for rewarding WTO countries that keep their trade regimes open while they address emerging transboundary and global environmental issues related to PPMs (11). Generally, a wide array of environmental trade measures could be advanced, each with very different legal, trade, and environmental implications. The expense of careful congressional review of these and other developments is low, given the potential for keeping agricultural trade open and addressing agroenvironmental problems worldwide.

ISSUE 3: ***Develop international institutions outside trade organizations to manage transboundary environmental issues related to agriculture.***

Many transboundary and global environmental phenomena either transcend trade or are better handled through forms of multilateral cooperation other than trade agreements. The Montreal Protocol on reducing ozone-depleting substances and the Rio Conventions on climate change and biodiversity are examples of such multilateral cooperation. Although there are more than 1,000 international environmental agreements, their overall effectiveness has not been assessed (chapter 5). The small number (about 20) that use trade measures appear to be effective. It is important to note, however, that existing multilateral environmental institutions do not have sufficient authority and resources to resolve complicated international environmental problems (2).

Addressing these transboundary and global issues will take time because the links between the environment and agricultural trade are poorly understood, management institutions are immature, and multilateral negotiation and collaboration are slow, costly processes. Immediate attention should be given to structuring productive agreements and institutions that help the United States avoid large environmental risks and keep international agricultural trade as unrestricted as possible. The two options delineated below build on each other to address the issue.

OPTION A: ***Congress could review international environmental management agreements affecting agriculture.***

Past efforts to address environmental problems beyond U.S. borders have generally been made on a case-by-case basis, as the negotiation and signing of the Convention on Trade in Endangered Species (CITES), NAAEC, and the Montreal Protocol demonstrate. This approach conserves negotiation, implementation, and enforcement resources, which are, as matters stand, expended only on problems that achieve international notoriety. So far, such agreements have not restricted trade in any major way. Nonetheless, this case-by-case approach is often reactive rather than proactive, especially with regard to management issues that hold potential for large-scale and irreversible environmental change. There are a few multilateral funding institutions that address international environmental problems—such as the Global Environmental Facility (GEF) of the World Bank, United Nations Development Program, and the United Nation's Environment Program—but at this writing they suffer from a lack of resources. The GEF fund, for instance, depends on voluntary contributions and appears to be far too small to contend effectively with the welter of global environmental problems it faces.

One agricultural trade problem that has resulted, in part from the implementation of international environmental agreements (and has been hotly debated in recent years) concerns methyl bromide. Widely used as a soil fumigant in producing certain crops, and for treating agricultural exports and imports, methyl bromide also depletes ozone and is targeted for reduction under the Montreal Protocol. EPA, under authority of the Clean Air Act, is planning to phase in a total ban on methyl bromide use in the United States by 2001. Estimates show that a reduction or ban would yield benefits far in excess of costs (7). But countries that are not taking such a stringent approach, or have not signed the Montreal Protocol, may consequently enjoy a competitive advantage in the international agricultural marketplace. Preliminary estimates indicate the ban would cause short-term annual losses of about $1.2 billion to agricultural producers and consumers, assuming that there are no new chemical substitutes for methyl bromide. A congressional review of possible federal actions that might help the U.S. agricultural sector adjust to the methyl bromide phaseout, such as technology research and development, would be extremely useful.

OPTION B: ***Examine the feasibility of a global management institution to treat adverse environmental consequences of agricultural trade expansion.***

Congress could initiate multilateral discussions on the adequacy of current institutions to address transboundary and global environmental problems that significantly affect U.S. interests. Commentators have suggested alternative approaches and institutions with different implications for U.S. involvement (2,3,11). A global environmental organization that would incorporate existing piecemeal programs could work with the WTO to ensure that economic and environmental agendas do not clash. As evolving science reveals new links among transnational environmental systems, and as nations' economies become increasingly globalized and interdependent, the benefits of comprehensively investigating linkages seem apparent. As with other policy options advanced in this section, the expense of the preliminary investigation would be minimal in comparison with the potential benefits.

Issues related to agricultural production, which has an impact on so much water and land around the globe, would be one element of the review. Many analysts believe, for example, that the greatest environmental challenges from liberalizing and expanding agricultural trade will occur in developing countries that have immature environmental management institutions. The proposed review could address this concern by coming up with a blueprint for precautionary management assistance to these countries. Another important function of the review could be to develop an information base that would help scientists and policymakers to anticipate the nature of likely environmental problems and possible research responses.

ISSUE 4: ***Foster private and public agroenvironmental technology transfer.***

Because the United States has developed considerable environmental management experience from almost three decades of programs, its industries have developed the capacity to competitively produce and export technology abroad. Environmental technology is in fact now a U.S. export growth industry, and it may serve national interests well by providing foreign countries with the training and technology to treat global/transboundary environmental problems that may eventually affect the United States. (New technologies for applying pesticides to minimize harm to nontarget wildlife species that migrate to U.S. territory are an example.) There is no major role for the federal government to play in promoting this market-based approach to remedy environmental problems. The government could, however, assemble information and conduct analyses to ensure market access for U.S. firms and to appraise targeted public research assistance.

Little is known about the applicability of environmental technology exports related to agriculture. As explained in chapter 4, environmental management in agriculture has not (unlike other industries) been highly regulated. As a result, the sectors supplying agroenvironmental technologies to domestic industry have been motivated mostly by subsidies rather than regulation. It is not clear if the dominant voluntary subsidy approach has yielded a competitive advantage in international environmental technology markets. Some new complementary production-environmental technologies, such as information-based nutrient management, could apparently be used in foreign settings.

The potential benefits of assisting other countries in dealing with environmental management problems that result from expanding agricultural production may warrant attention from the public and private sectors. The public interest is in managing transboundary or global environmental resources; the private interest is potential export earnings. Two options explored below would help both parties reap benefits from agroenvironmental technology trade.

OPTION A: ***Assemble an information base on trade in agroenvironmental technologies.***

Both public agencies and private firms need information about the status, trends, and obstacles confronting them in marketing agroenvironmental technologies abroad. Although the international trade market in environmental technology appears relatively open, the particular problems and opportunities for the agriculture sector have not been systematically investigated.

Ensuring sufficient effort to achieve environmental goals may require more than open private markets—some public activity may be necessary. NAAEC, for example, is investigating transborder environmental problems and how environmental technologies might be used to alleviate them. Public policies that discourage or inhibit particular technologies that promote environmental protection, such as burdensome registration processes for new chemical or biological pesticides, may require governmental attention. Congressional hearings on issues related to agroenvironmental technology trade could help assemble the first information base on the subject.

OPTION B: ***Authorize a multilateral public-private panel on agroenvironmental technology transfer.***

Environmental technologies seem to face relatively few trade barriers, as noted above, and little government involvement appears necessary to make the industry a beneficial force for promoting the health of the domestic and international environment. The full potential for sharing agroenvironmental technologies that address key transboundary and global environmental management questions cannot, however, be realized by private markets alone. Certain cases will require more government assistance.

Where transboundary or global environmental issues exist, the management problem becomes more difficult because multiple governments and complex negotiation become necessary. The protection of plant and animal species diversity that serves production and environmental needs outside one country's borders is a good example. Expanding agricultural production and environmental change in foreign countries from trade liberalization raises the issue of technology transfer to address these issues.

Convening an international panel on agroenvironmental technology transfer to design institutions and procedures for promoting the public and private diffusion and voluntary adoption of human, biological, and physical technologies would be a low-cost first step. Some programs already under way at the Organization for Economic Cooperation and Development are investigating ways to promote such transfers, and increased congressional attention would aid such efforts. Improved market access for U.S. companies would likely result from such initiatives, as well as public-private collaborative technology research and development.

EPILOGUE

This chapter has presented policy options for agriculture, trade, and the environment that illustrate how policies can be complementary rather than in conflict. As the United States heads into the next millennium such complementarity could have a key influence on the standing of U.S. agriculture in a global economy. Indeed, seeking complementarity among these policies will allow the United States to capture the opportunities of global market expansion while protecting and advancing domestic goals related to environmental quality as well as to the competitiveness of the agricultural sector. Moreover, seeking complementary and mutually reinforcing policies will likely lessen budget pressures. Equally important, pursuing complementarity can help ensure that the nation's policies are oriented to the future, not anchored to the past.

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